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## LLAFFS - A Lightning-Locating and Fire-Forecasting System

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United States  
Department of  
Agriculture

Forest Service

Intermountain  
Forest and Range  
Experiment Station  
Ogden, UT 84401

Research Paper  
INT-315

July 1983



AUG 18 1983

# LLAFFS - A Lightning- Locating and Fire- Forecasting System

Don Latham

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73-13 A13-78:INT-315

## THE AUTHOR

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## RESEARCH SUMMARY

This publication contains programs and documentation to implement an algorithm for calculating lightning fire probability. This calculation is based on a model originally developed for the National Fire-Danger Rating System. The model algorithm estimates the probability that a lightning discharge from cloud to ground will ignite a fire in fuels at the ground terminus of the lightning. Probability is estimated using variables that are measures of the fuel state and type, rain, and lightning. Details of the model can be found in Fuquay and others (1979), Latham (1979), and Fuquay (1980).

The lightning-locating and fire-forecasting (LLAFFS) system is designed to combine ignition probability with real-time lightning occurrence, and to transmit the results to the land manager. The lightning occurrence is assumed to be given by a Lightning Location and Protection, Inc., Position Analyzer in the form of a time, latitude, and longitude estimate for each lightning event in the area covered by the analyzer. The system programs use weather variables and the state of the fuels for the place the lightning hit ground; the algorithm is used to calculate the probability that the discharge started a fire. Probabilities are added with varying time scales to provide running totals that are recorded by the programs.

The land manager needs to know the location of probable fires. The transmission of this information must be cost-effective and the output convenient to use. We have developed a method for storing and transmitting lightning fire probability data using a simple printing terminal as a user interface device. The area occupied by a character on a printed page of text, called a pixel, is made to correspond to a geographical area on a map. An array of printed characters can thus be used with transparent overlays. The overlays "store" permanent information such as lookouts, roads, political boundaries, geographic features, equipment centers, areas of responsibility, or other desired data.

The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture of any product or service to the exclusion of others that may be suitable.

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# LLAFFS A Lightning-Locating and Fire- Forecasting System

Don Latham

## 1.0 INTRODUCTION

This publication contains programs and documentation to implement an algorithm for calculating lightning fire probability, developed at the Northern Forest Fire Laboratory, Intermountain Forest and Range Experiment Station. The calculation of lightning fire probability is based on a model originally developed for the National Fire-Danger Rating System. The model algorithm estimates the probability that a lightning discharge from cloud to ground will ignite a fire in fuels at the ground terminus of the lightning. Probability is estimated using variables that are measures of the fuel state and type, rain, and lightning. Details of the model can be found in Fuquay and others (1979), Latham (1979), and Fuquay (1980).

The lightning-locating and fire-forecasting (LLAFFS) system (figs. 1 and 2) is designed to combine ignition probability with real-time lightning occurrence, and to transmit the results to the land manager. The lightning occurrence is assumed to be given by a Lightning Location and Protection, Inc. (LLP) Position Analyzer in the form of a time, latitude, and longitude estimate for each lightning event in the area covered by the analyzer. The system programs use weather variables and the state of the fuels for

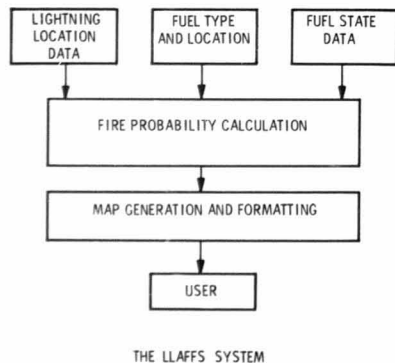


Figure 1.—Overall functional diagram of the LLAFFS system.

the place the lightning hit ground; the algorithm is used to calculate the probability that the discharge started a fire. Probabilities are added with varying time scales to provide running totals that are recorded by the programs.

The land manager needs to know the location of probable fires. The transmission of this information must be cost-effective and the output convenient to use. We have developed a method for storing and transmitting lightning fire probability data using a simple printing terminal as a user interface device. The key to the method is that the area occupied by a character on a printed page of text, called a pixel, can be made to correspond to a geographical area on a map. An array of printed characters can thus be used with transparent overlays. The overlays "store" permanent information such as lookouts, roads, political boundaries, geographic features, equipment centers, areas of responsibility, or other desired data.

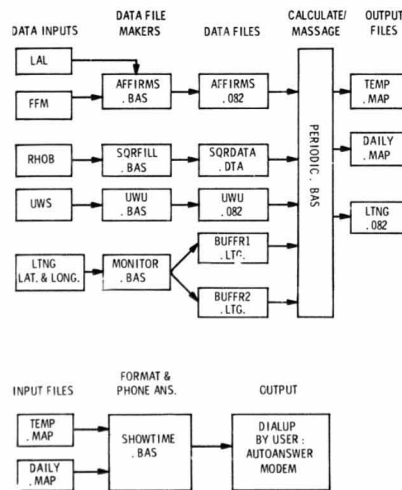


Figure 2.—Data flow, programs, and files of the LLAFFS system.

Figure 2 presents a data flow block diagram of LLAFFS. In use, the system runs as follows:

- The data file maker programs are periodically applied by the LLAFFS (not the field user) operator to provide current environmental data,
- which, along with real-time lightning location data, are turned into data files to be read by the probability calculation program,
- whose output files become input files to the "telephone operator,"
- which a field user calls on his/her terminal for the formatted fire probability data.

Our implementation of the LLAFFS system was done on a minicomputer. The programs, written in BASIC, were structured to match its capability for handling several programs and several users at the same time. If such a machine is not available, the programs may be adapted for use with a smaller machine, such as some of the commonly available microcomputers.

## 1.1 COMPUTING MACHINERY REQUIRED

The minimum machinery necessary to run LLAFFS would be a microcomputer, printer, and modem(s). This equipment will enable acquisition of AFFIRMS data, control of an LLP Position Analyzer (or reception of data from one), and output of printed data for local use with overlays. Overlays also work very well on the front of CRT displays; even the printer might be unnecessary for some applications (although recommended). More than one modem will be required for dial-up access. Interrupt-driven software is necessary if a multitasking/multiuser operating system is not available.

The following sections of this package contain technical information for implementation. For an overview, the reader may skip to section 2.5.1.

## 2.0 INFORMATION FLOW: SYSTEM BLOCK DIAGRAM

Figure 2 presents the overall data flow for the LLAFFS system. The data inputs consist of Lightning Activity Level (LAL), fine fuel moisture (FFM), fine fuel bulk density (RHOB), upper windspeed (UWS), and lightning locations (in latitude and longitude) from the position analyzer. Only the lightning locations are on-line (real-time) inputs; the others are entered manually at the host computer. All information between system programs is passed through files.

### 2.0.1 Data Inputs—Geographical Assignment

The implementation of LLAFFS should begin by choosing a suitable overlay map scale, pixel size, and map limits (fig. 3). The map limits and pixel size are used by the computer programs only in PERIODIC.BAS (see 2.4.1 and flowchart, appendix C). The program SQRFFILL.BAS (see 2.2.1) uses index numbers only and has no explicit geography. A guide map, or the overlay master map, must be used to decide the fuel types and AFFIRMS reporting stations to be used.

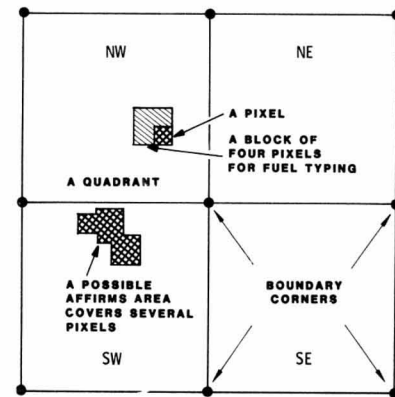


Figure 3.—LLAFFS system geometry/geography.

## 2.1 DATA INPUTS DESCRIPTION

The ignition model requires Lightning Activity Level as one of its inputs. Fuquay (1980) explains the meaning of this number, and provides simple methods of estimation. Although the LAL specifies a number of lightning strokes, the actual number is used in computation. Another variable required is the steering windspeed for storms in the area of interest. The Weather Service standard 500-millibar windspeed can be used with little error. The fuel bulk density can be estimated as shown in Fuquay and others (1979). This variable is important in the calculation; be sure it is as accurate as possible. If none of the fuel models described in table 5 of the above paper fits exactly, however, the closest approximation will have to do. In general, RHOB for long-needled conifers will be 4 pounds per cubic foot, short-needled conifers 6 to 8, grass 2, and broadleaf species 4. The remaining input variable, fine fuel moisture, is available from AFFIRMS or is calculated according to the National Fire-Danger Rating System. If a different rating system is in use, then some means of conversion to the NFDRS 1-hour timelag moisture content must be applied.

## 2.2 DATA FILE MAKERS

The data file maker programs are used to set up the LLAFFS system and update some of its inputs. We will discuss the programs in the order in which they are applied in use. The flowcharts and program printouts can be found in appendix C. **Note that all LLAFFS files except SQRDATA.DTA must be externally created at the initial implementation of the system.**

## 2.2.1 SQRFFILL.BAS

This program creates a file SQRDATA.DTA, which contains a bulk density (RHOB) and AFFIRMS station code number for each of the pixels. The pixels are grouped into blocks of four (fig. 3). Each block of four has an AFFIRMS station assigned to it. Some stations will be assigned to more than one block. The stations are chosen by the user to be most representative for Lightning Activity Level and fine fuel moisture data. This program will probably be used very seldom, because the bulk densities for the pixels, as well as AFFIRMS stations, will not change appreciably over a season and probably very little from season to season. For this reason, SQRFFILL is not a very "user friendly" program. Details of the file format are in section 2.3.2.

## 2.2.2 AFFIRMS.BAS

This is a program which prompts the user to enter LAL and FFM values for each selected AFFIRMS reporting station in the area covered by the maps. The number of stations will vary by the application (fig. 3). Our application used 73 stations. Several pixels on a map may use FFM and LAL information from the same AFFIRMS station (2.2.1). The file AFFIRMS.082 is updated and passed to PERIODIC.BAS. PERIODIC.BAS, by knowing a pixel's AFFIRMS station code number, assigns the appropriate values of FFM and LAL to a pixel. We wished to keep a running record of the AFFIRMS data. Because of this, the file AFFIRMS.082 can be extended each time AFFIRMS.BAS is run. It is unlikely that this will be desired in most applications, so we have provided for rewrite or append functions in this program. If data files are not desired, answer "R" (rewrite) at the "Rewrite (R) or Append (A)" prompt. Choice of rewrite mode will wipe out all data that may have been filed from previous append mode operations, so take care here.

## 2.2.3 UWU.BAS

UWU.BAS creates a file called UWU.082, which is used when PERIODIC.BAS updates the upper windspeed variable. In general, the upper windspeed value will be the same for most of the pixels. The version of the program given here passes, to UWU.082, the current values of the upper windspeed at three stations and the date and time. The actual calculation of the UWS values for each pixel is done in PERIODIC.BAS. As with AFFIRMS.BAS, we have an append or rewrite choice. The rewrite choice will wipe out any data left from previous append mode operation. Take care when answering "Append (A) or Rewrite (R)" if data files are to be kept.

## 2.2.4 MONITOR.BAS (SUPERMON.BAS)

The lightning data from an LLP Position Analyzer is received and filed by this program. In our application, MONITOR is an interactive task running on a multitasking machine. There is more than one input data stream for lightning data in this version of the monitor program, as well as some communication with other computers. Our program is included in the package for completeness and as an example for generating the buffer files in the correct format for PERIODIC.

The lightning data go into one of two buffer files, as input for PERIODIC.BAS. These files, BUFFER1.LTG and BUFFER2.LTG (2.3.4), are necessary to prevent loss of data during the running of PERIODIC. If the machine running these programs is not multitasking, then a different MONITOR will be necessary to prevent lost lightning data. One possibility is an interactive program to take advantage of the core storage in the Position Analyzer. Other schemes depend on the available hardware.

## 2.3 DATA FILE DESCRIPTIONS

As we have seen, there are five intermediate data files within the LLAFFS system. These contain the updated values of the input variables. The files are inputs to the probability predictor and output file maker program, PERIODIC.BAS. Depending on the type of computer being used as the host, the data files may be updated interactively at any time, except when PERIODIC is reading them (2.2.4, 1.1). We will describe the file contents in the order shown in figure 2.

### 2.3.1 SQRDATA.DTA

This file, created within SQRFFILL.BAS, contains encoded bulk density and AFFIRMS station code numbers for each block of a 24 by 24 array, hence its length of 576. The number of blocks depends on the implementation. Each record contains a number that tells PERIODIC.BAS which AFFIRMS data station and RHOB index are to be used. Each square is representative of a block of four pixels in the final map. Both pieces of information are combined into a single number in the file. The form of this number is (station number \* 100) + RHOB index.

### 2.3.2 AFFIRMS.082

The first record in this file is the record number of the last record written. The subsequent data items are packed into nine records; they contain the latest data produced by AFFIRMS.BAS. The first value in the nine records is the time in minutes from January 1 of the year that the AFFIRMS data was measured. Next are values for FFM and LAL, one for each reporting weather station. These values are coded (multiplexed) by AFFIRMS.BAS into a single number for each station for efficient packing. The form of this number is (LAL \* 100) + FFM. The number of AFFIRMS stations will vary according to the application; we used 73. It is important to note that the number of variables is not the same as the number of records in the file; there are nine records, one for each BASIC "outfile" statement. If the rewrite mode is chosen, the file is wiped clean; any data that has been entered in append mode will be lost.

### 2.3.3 UWU.082

As with AFFIRMS.082, this file, created externally at implementation, can either be appended to or rewritten. The number of records depends on whether the append mode or the overwrite mode is used in UWU.BAS. The first record contains the record number of the beginning of the latest data written. Then follows a record with the calculated local time in minutes since the beginning of the year that

the observations were taken (as in AFFIRMS.082) and three wind speeds. A different time code scheme can be used. The appended file will grow continuously. If the rewrite mode is chosen at any time, all data from an appended file will be lost.

### 2.3.4 BUFFER1.LTG and BUFFER2.LTG

These are two identical files containing lightning data to be read by PERIODIC. They are identical in format, and random in length. They must be initially created at implementation of LLAFFS. They are alternately read and flushed so that the maximum size of either would be in the neighborhood of 2,000 78-byte records.

## 2.4.1 PERIODIC.BAS—The Main Program

PERIODIC.BAS (fig. 4) is the workhorse for LLAFFS. This program, running as a background task, performs the following functions:

- (1) takes in the values of the input variables (RHOB, FFM, LAL, UWS) from the AFFIRMS.082, SQRDATA.082, and UWU.082,
- (2) takes in lightning data from BUFFER1.LTG and BUFFER2.LTG,
- (3) gets the appropriate values of variables and lightning for each pixel from the files,
- (4) calculates the probability of ignition per discharge in each pixel,
- (5) updates the half-hour (or other selected interval) maps,
- (6) updates the cumulative (daily) maps, and
- (7) generates archival files.

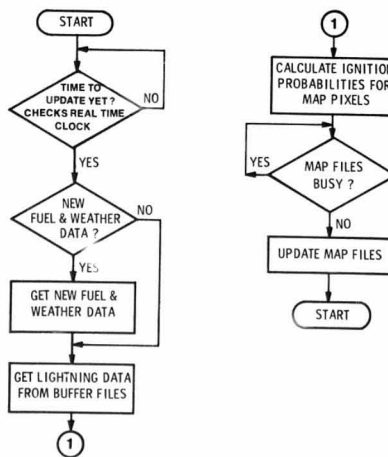


Figure 4.—PERIODIC.BAS functional diagram.

Input files to PERIODIC are discussed in section 2.3. The output files (see 2.4.2) are TEMP.MAP, DAILY.MAP, and LTNG.082. PERIODIC also uses four files for temporary storage as it runs. These are BUFR.MAP, LTOTL.DTA, and HALFHR.CNT. The temporary files are created when the system is implemented. The first of these temporary files is used in merging the last interval's data with the DAILY.MAP file. The second, LTOTL.DTA, contains total lightning strikes for pixel groups. The third, HALFHR.CNT, contains the lightning counts by pixel for the last half-hour time period. This file is put in BUFR.MAP and a new HALFHR.CNT is calculated. The fourth file contains communications between PERIODIC and MONITOR to tell MONITOR which lightning location buffer file (see 2.3.4) to use.

The host computer must have a real-time clock so that PERIODIC will know what time it is. The update interval and the beginning-time of the 24-hour DAILY.MAP file are set in PERIODIC. For optimum machine use, PERIODIC should be called from an interrupt routine in the operating system, instead of having a loop as our version does. Indeed, if the system is to be installed on a non-multitasking machine, MONITOR must be the control program, running all the time, and contain a call to PERIODIC. The two programs can call each other using a chain command because all information is passed in files. A single-user machine may lose some data during the PERIODIC running time, unless interrupt-driven software has been devised.

### 2.4.2 PERIODIC.BAS Output Files

PERIODIC.BAS (figs. 2 and 4) uses three output files, TEMP.MAP, DAILY.MAP, and LTNG.082. The files are created externally when LLAFFS is implemented. The last is archival and will not be discussed. TEMP.MAP contains the latest half-hour counts and DAILY.MAP the cumulative count for the current day. The beginning of the day is set in PERIODIC.

The structure of TEMP and DAILY are shown in figure 5. Each record after the first five contains three variables. The first is the row and column of the pixel to which the data belong. The second variable is the number of lightning discharges that the location equipment claims has struck the ground in the area represented by the pixel. The third is the probability per discharge of an ignition in the area represented by the pixel. The product of probability per discharge and the number of discharges, although not exact, is used for the probability that an ignition will occur within the ground area represented by the pixel.

A listing and flowchart for PERIODIC are in appendix C.

## 2.5 SHOWTIME.BAS, The Output Program

SHOWTIME (figs. 3 and 6) is designed to read the output files DAILY.MAP and TEMP.MAP and format them into printer-compatible form for output to the user. A listing and detailed flowchart of SHOWTIME are included in appendix C.

The program has been optimized to reduce printing time to a minimum. Rows in the output map having no data are output as a carriage return-linefeed pair. The row is truncated at the last pixel having data in it. Maps with no data are not printed, and a "no data" statement is output in place of the map.

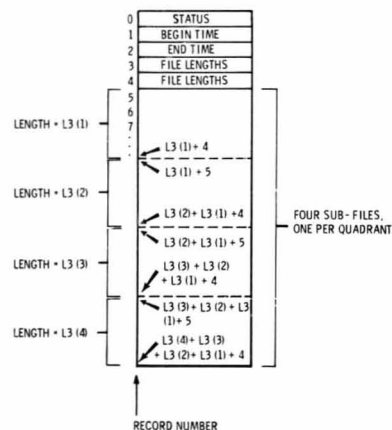


Figure 5.—DAILY.MAP and TEMP.MAP file structure.

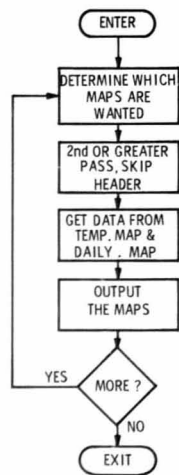


Figure 6.—SHOWTIME.BAS functional diagram.

## 2.5.1 OUTPUT FORMAT

Examples of SHOWTIME.BAS output are shown in figures 7 and 8. In these examples, each pixel represents an area on the ground of about 3 miles by 3 miles. There is, of course, nothing sacred about this size—it can be changed by altering the programs (see 2.0.1) and overlay maps to suit the occasion.

The lightning density map (fig. 7) is straightforward. An "X" is placed as an index mark in the upper and lower left corners of the printout. The index mark is keyed to the overlay. Each pixel contains a number. This is the number of strikes the location system says have hit within the corresponding overlay area on the ground. Zeroes are suppressed, and more than nine strikes in a pixel is represented by an "X". The time period is specified in the text accompanying the printed map.

The fire probability map (fig. 8) is almost as simple. The numbers do not indicate the number of fires expected in each pixel. The numbers are codes representing the probability of a fire being in the pixel. We have tentatively set them as follows: a blank is zero probability, a "1" means probability between 0 and 0.2 or a 20 percent chance of a fire, a "2" is between 0.2 and 0.4 or between 20 and 40 percent, a "3" is between 0.4 and 0.8 or between 40 and 80 percent, and a "4" means that there is a probability greater than 0.8 or 80 percent that there is a fire in the pixel. This coding enables us to put the probabilities in a single number for the pixel. Users who prefer a different coding scheme or levels are welcome to do so, provided the actual calculation of the probabilities is not changed. The values are set in a subroutine within SHOWTIME.

Information on the printout could also represent other variables related to an area on the ground, if the variables can be represented as a single character. The generation of extra information would go into SHOWTIME. A possible use might be a simple fire-danger map, or a rate-of-spread code. To do this, more files and additions to PERIODIC would have to be created.

## 2.5.2 Warning

Research indicates that the accuracy of the lightning ground strike points is not routinely better than the 3 miles we have used for our pixel size. Indeed, in some cases the error may be larger than twice that amount. This means that the lightning locations and fire probabilities may be "off" by at least one pixel, possibly more, in any direction. More research is being done on accuracy.

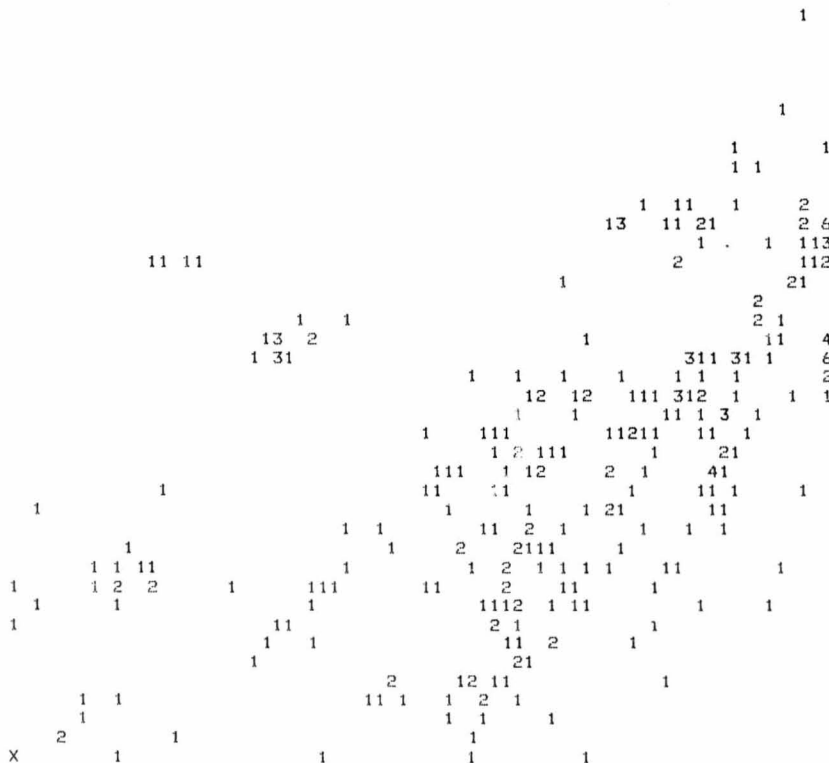
THIS IS THE SOUTHWEST CUMULATIVE LIGHTNING MAP.  
THIS MAP COVERS THE PERIOD

FROM : 08/11 11:00 (MDT)

TO : 08/12 09:40 (MDT)

\*\*\*\*\*

X



THERE WERE 296 STRIKES IN THE QUADRANT.

\*\*\*\*\*

Figure 7.—A typical lightning density map generated by SHOWTIME.

THIS IS THE SOUTHWEST CUMULATIVE EXPECTED FIRE MAP.

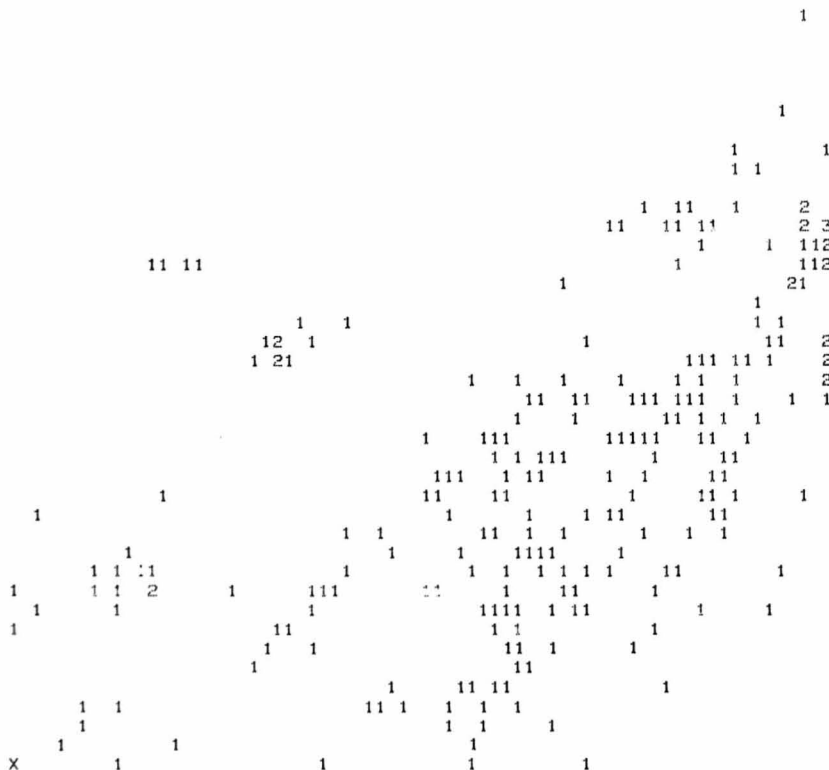
THIS MAP COVERS THE PERIOD

FROM : 08/11 11:00 (MDT)

TO : 08/12 09:40 (MDT)

\*\*\*\*\*

X



THERE WERE 230 SQUARES EXPECTING FIRES.

\*\*\*\*\*

Figure 8.—A typical fire probability map generated by SHOWTIME.

## 2.6 FIELD USE

The field user (Forest level) will need a set of instructions for use of LLAFFS. The instructions we used for our field trial are included as appendix A. The important elements of these instructions are:

- Dial-up or other access instructions must be clear and detailed; a lot of inquiries and "handholding" will be saved by overkill in the instructions.

- The map areas covered by the printout pixels must be clearly stated and related to familiar geography.

- Overlays must be simple and easily read. More than one overlay map covering the same area is better than a single one with too much information on it.

- The meanings of the numbers on the printouts must be clearly stated.

Overlays for our application are not included in this package because of their cost and provinciality. We have had some success with overlays made from simple hand-drawn maps such as that of figure 9. These are copied using a transparency copier such as those used for making overhead projections. If desired, information to help users with this procedure might be given as part of the field guide. Transparencies may have to be tailored for use with varying kinds of terminals, because terminal print sizes are variable. If the users are using only one terminal or one kind of terminal, this tailoring will not be necessary.

Appendix B contains a sample user run of the LLAFFS output. The message section at the beginning of the run is generated by the operating system of our host computer. If this is desired in other implementations, it could be part of SHOWTIME. To avoid modifying the program each time the message is to be changed, put the message in a file and access it in the SHOWTIME program.

## 2.7 CONCLUSION

The programs which are included in this package were all developed in BASIC for use on a Perkin-Elmer 3200 machine. Adaptation to other computers may require some program rewriting. In particular, file handling syntax may be considerably different. Smaller machines may require more intermediate files because of memory limitations. It may also be desirable to automate the map output instead of having a dial-in system. See also the comments in sections 1.1 and 2.2.4.

NOTE: Portions of the programs having to do with probability calculation must not be changed without consultation. To make such changes will invalidate the predictions. If this warning is heeded, the system presented in this package will improve the use of lightning location networks for fire management.

## OVERLAY NO.1 NORTHWEST

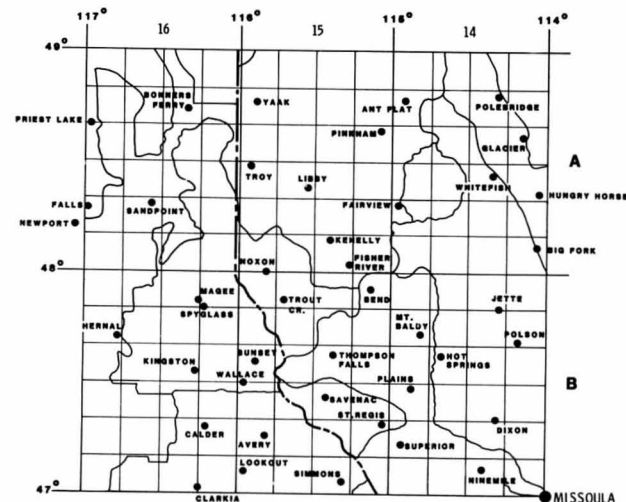


Figure 9.—A sample overlay map.



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## APPENDIX A SAMPLE INSTRUCTIONS\*

### Dialin Lightning

This is the instruction sheet for using experimental lightning location and fire probability maps. The maps are a joint effort between Aviation and Fire Management of Region 1 and the Intermountain Forest and Range Experiment Station, Northern Forest Fire Laboratory. Our objective is to make available both current and cumulative information on lightning occurrence and probable fire starts. The information is in the form of simple printouts designed to be used with a Regional overlay map. The computer that generates the printouts is located at the Fire Laboratory. The Regional Coordinator's office plans to alert users through the Weather teletype network, and distribute the maps and instructions for use. The printouts can be obtained using a 300-baud printing terminal, such as an Execuport. The terminal may have either 80 or 132 print columns. The printouts, an example of which accompanies these instructions, are designed to be used with the overlay maps, also supplied.

The Regional overlay map has been divided into four quadrants: NW, NE, SW, and SE. The center of the quadrants is at 47 degrees north latitude and 114 degrees west longitude. Each quadrant covers two degrees in latitude and three in longitude:

- NORTHWEST: 47-49 N and 114-117 W, includes part or all of the Kaniksu, Kootenai, Flathead, Coeur D'Alene, Lolo, and St. Joe Forests,
- NORTHEAST: 47-49 N and 111-114 W, includes the Flathead, Lewis and Clark, Lolo, and Helena Forests,
- SOUTHWEST: 45-47 N and 114-117 W, includes the St. Joe, Clearwater, Lolo, Nezperce, and Bitterroot Forests,
- SOUTHEAST: 45-47 N and 111-114 W, includes the Lolo, Helena, Deerlodge, Beaverhead, and Gallatin Forests.

The printouts are made with an X in each of the upper and lower left-hand corners. These are to be aligned with the leftmost top and bottom boundary corners of the appropriate quadrant of the overlay map. For example, if the quadrant on the printout is the NE, the top X goes under 49N, 114W and the bottom X under 47N, 114W and so on. Those of you with map experience will note that the registration of the overlay and the map is not perfect. That is because the printouts are "flat earth" and the maps are projections. Expect errors of at least one pixel (that is jargon for one character space on the printout map) in all directions, and more toward the top of the upper half of the overlay and the bottom of the lower half.

\*Note: These sample instructions are from an experiment and are for user guidelines only. Telephone numbers are now different, and LLAFFS is no longer experimental.

There are 16 available printout maps, 4 for each quadrant. These are:

- a lightning occurrence map updated each half-hour,
- a cumulative lightning map, beginning each day at 0400 hours,
- a fire probability map updated each half hour, and
- a cumulative fire probability map, beginning each day at 0400 hours. The numbers on the lightning maps represent the number of discharges to the area represented by that pixel (one character space), for both the 1-hour and the cumulative maps.

The fire probability maps have been scaled. The probability of fire for each pixel is reduced to a single number from zero to four. The zeroes are not printed for better clarity. These characters do not translate directly into numbers of fires. That is, a "1" in a pixel does not mean one fire in that area, rather a low but not zero probability of a fire. The same is true for a "2", and so on. The larger the number, the greater the chance that there is a fire near the area represented by the pixel. Remember that this area is larger than it appears because of the accuracy limitations of the equipment and the overlay display technique.

Now, how can you get the maps? That is the easy part. First, get hold of a 300-baud terminal that can hook up to a phone line. Then, dial 329-3870, commercial, or 585-3870, FTS. When you hear the tone, stick the phone in the terminal (if it is that kind). Type a few letters and hit return; the message \*SIGNON REQUIRED should appear. If it does not, the computer is down or the terminal is not making contact. Try once more, and if there is no response, the computer is probably down.

If the message \*SIGNON REQUIRED, followed by a new line beginning with an \*, is received, type in SIGNON ID,125,LTNG, then return. Do not forget the commas, and do not leave any spaces except for one after the word SIGNON. Put the forest ID initials in position ID or some other ID letters for other users. Do not use numbers. ID may be from one to four letters long. The computer will respond with the program SHOWTIME, which begins with the date and time and should proceed as shown in the examples we have provided. Some time may elapse before the response, but a minus sign (-) will appear right away to show that you are hooked up. If you have difficulties and have struggled with them for a while, call us at 585-3494, FTS, or 329-3494, commercial. If the computer is down, try later.

Please remember that this is an experiment. We are not staffed for a 7-day week, 24-hour day, but we will do the best we can. We would like to have your comments. Either pass them through the Regional dispatch center or send them directly to Don Latham at the Northern Forest Fire Laboratory. We are especially interested in documented comments regarding accuracy.

## APPENDIX B

### A SAMPLE FIELD RUN OF LLAFFS

SIGNON REQUIRED<sup>125</sup>LTNG  
\*SIGNON DON,125,LTNG

-08/12/82 10:24:32

- LIGHTNING LOCATION AND FIRE FORECAST SYSTEM (LLAFFS)

-NEWS -- 08/11/82  
-ALL SYSTEMS GO.

-WHICH QUADRANT WOULD YOU LIKE TO SEE ? (NW,NE,SW,SE)  
>SW

## OPTIONS

## LIGHTNING MAPS

1. LAST HALF HOUR
2. CUMULATIVE

EXPECTED FIRE MAPS

3. LAST HALF HOUR  
4. CUMULATIVE

OTHERS

5. 1 AND 2
6. 3 AND 4
7. 2 AND 4

ENTER AN OPTION NUMBER

27

THIS IS THE SOUTHWEST CUMULATIVE LIGHTNING MAP.  
THIS MAP COVERS THE PERIOD

FROM : 08/11 11:00 (MDT)  
TO : 08/12 09:40 (MDT)

\*\*\*\*\*

X

A sparse matrix plot of the adjacency matrix of a graph with 26 vertices. The vertices are arranged in a hierarchical, tree-like structure. The matrix is symmetric, with non-zero entries (represented by '1's) indicating edges between vertices. The plot shows a clear pattern of connectivity, with many vertices having only one or two neighbors, and a few central vertices having more connections. The overall shape is roughly triangular, with the highest density of edges in the upper right quadrant.

THERE WERE 296 STRIKES IN THE QUADRANT.

XX



# BEST DOCUMENT AVAILABLE

THIS IS THE SOUTHWEST CUMULATIVE EXPECTED FIRE MAP.

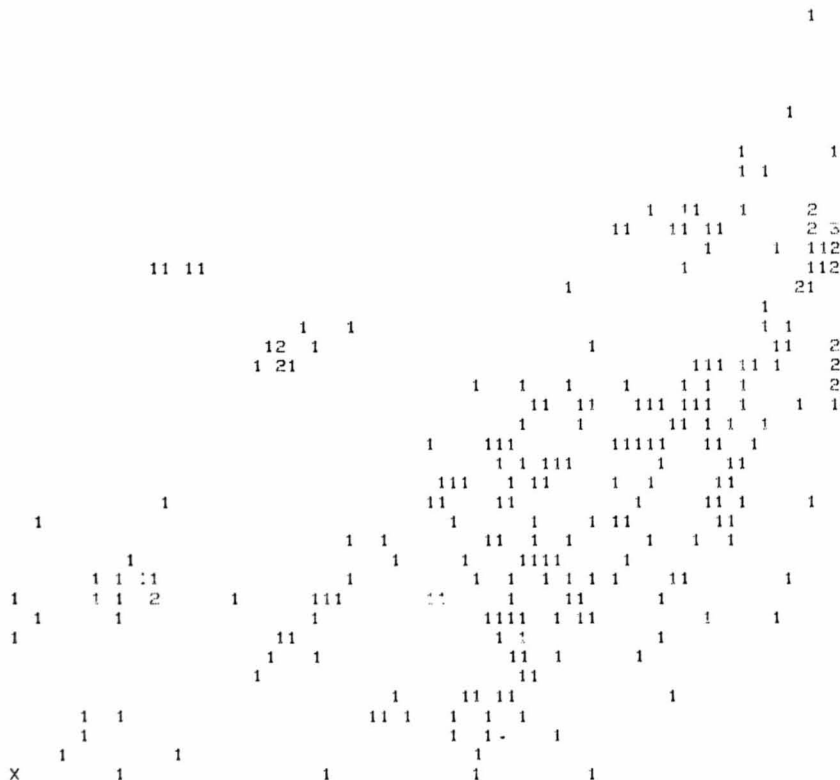
THIS MAP COVERS THE PERIOD

FROM : 08/11 11:00 (MDT)

TO : 08/12 09:40 (MDT)

\*\*\*\*\*

X



THERE WERE 230 SQUARES EXPECTING FIRES.

\*\*\*\*\*

MORE MAPS ? (Y OR N)

>Y

WHICH QUADRANT (NW,NE,SW,SE)

>SW

OPTION NUMBER

>7

# BEST DOCUMENT AVAILABLE

THIS IS THE SOUTHEAST CUMULATIVE LIGHTNING MAP.

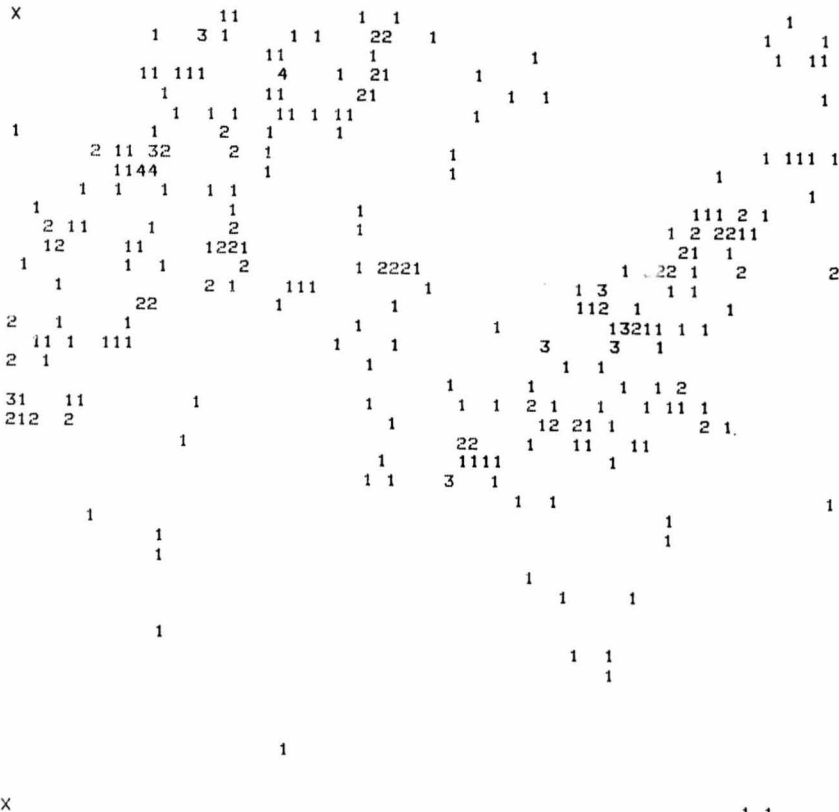
THIS MAP COVERS THE PERIOD

FROM : 08/11 11:00 (MDT)

TO : 08/12 09:40 (MDT)

\*\*\*\*\*

X



X

THERE WERE 313 STRIKES IN THE QUADRANT

\*\*\*\*\*

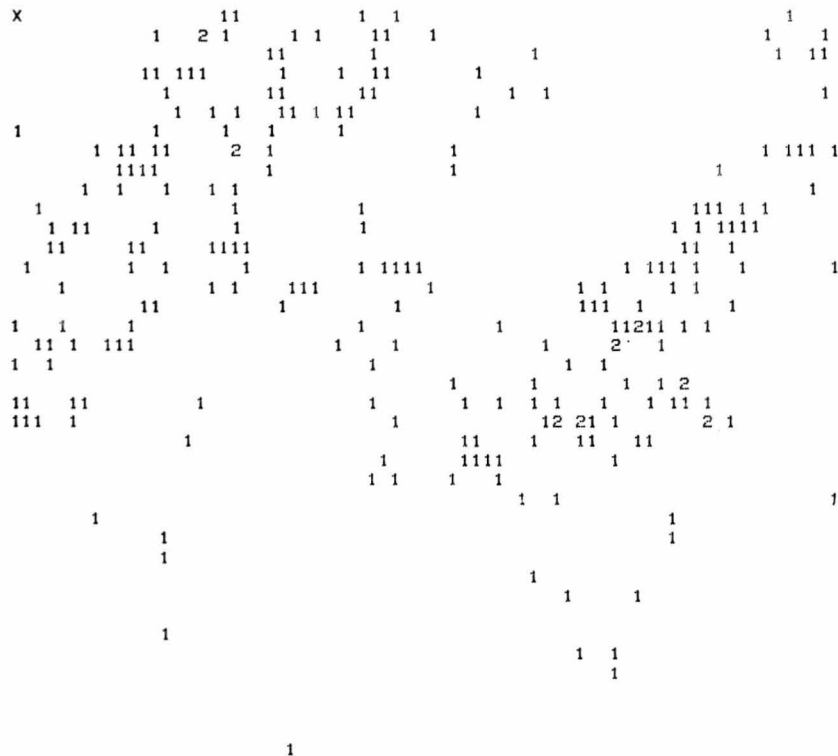
THIS IS THE SOUTHEAST CUMULATIVE EXPECTED FIRE MAP.

THIS MAP COVERS THE PERIOD

FROM : 08/11 11:00 (MDT)

TO : 08/12 09:40 (MDT)

\*\*\*\*\*



X

1 1

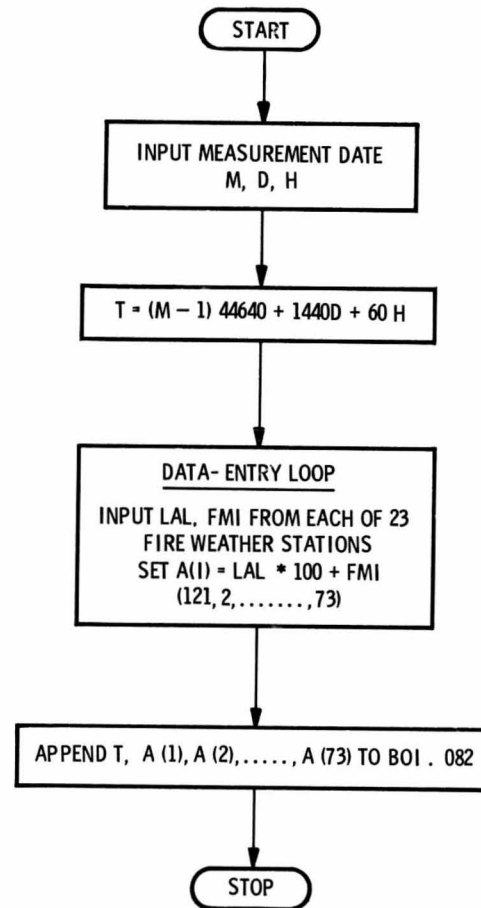
THERE WERE 243 SQUARES EXPECTING FIRES.

\*\*\*\*\*

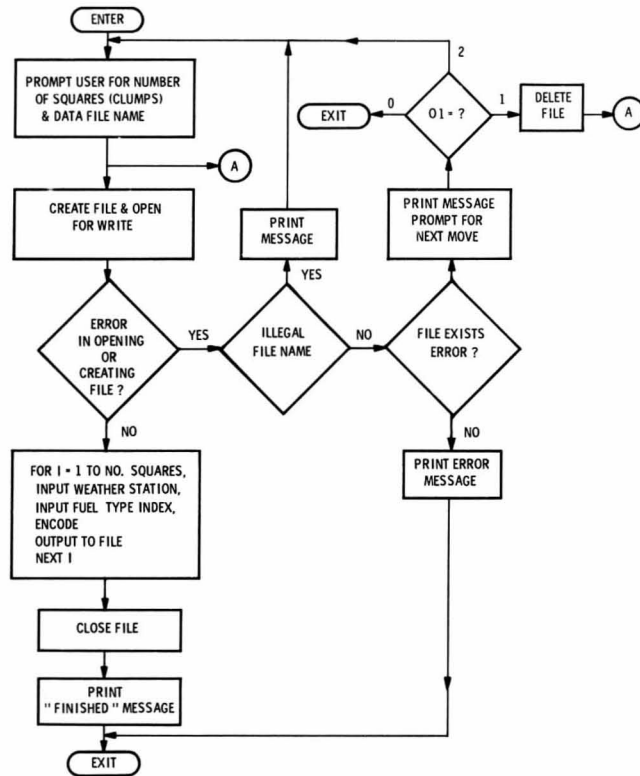
APPENDIX C

FLOW CHARTS AND PROGRAMS

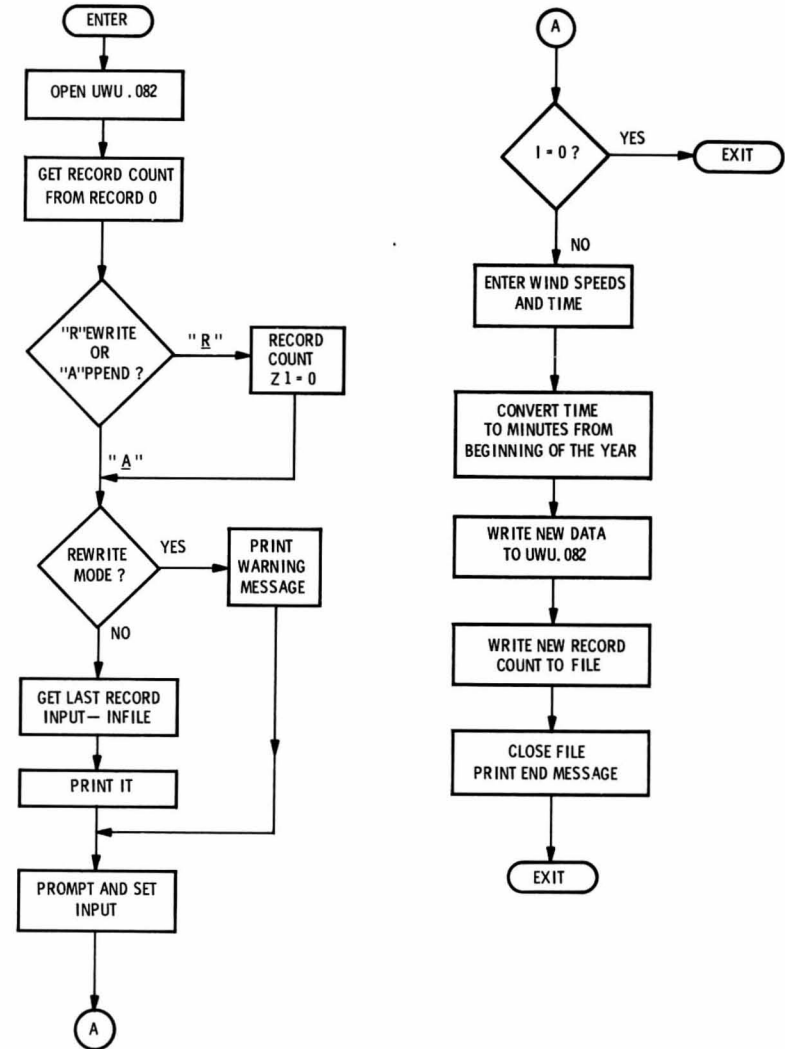
AFFIRMS DATA UPDATER



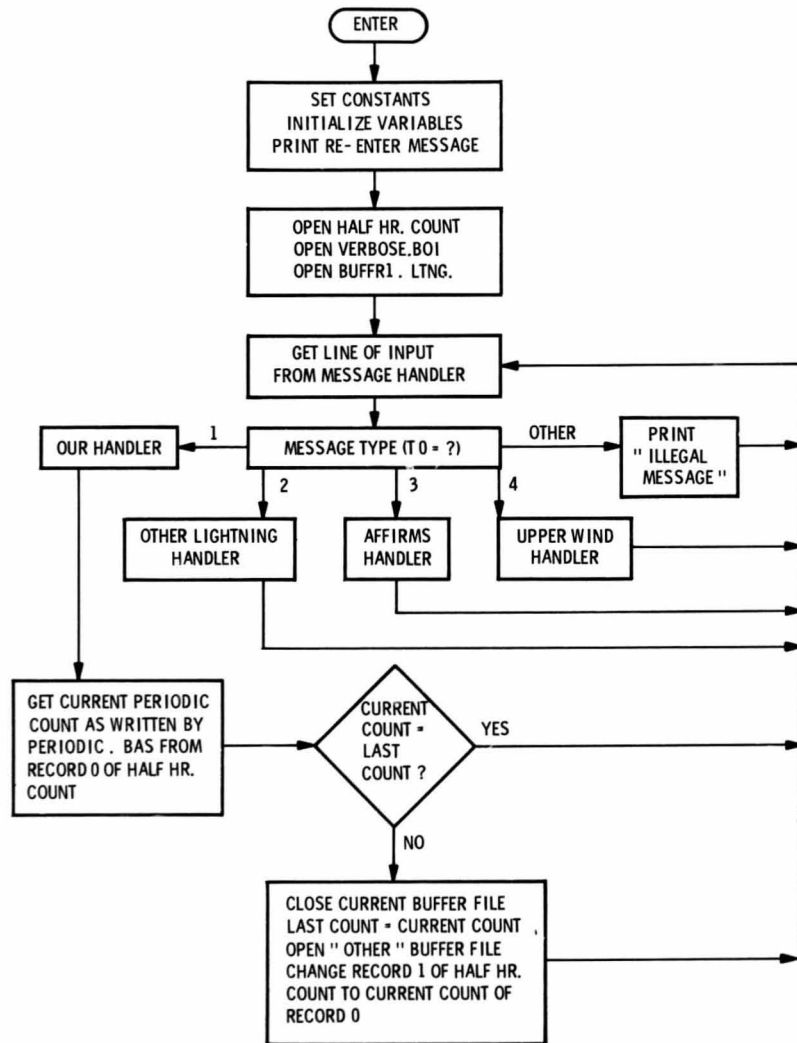
SQRFIL . BAS



UWU . BAS



SUPERMON . BAS



SUPERMON . BAS  
(Page 2)

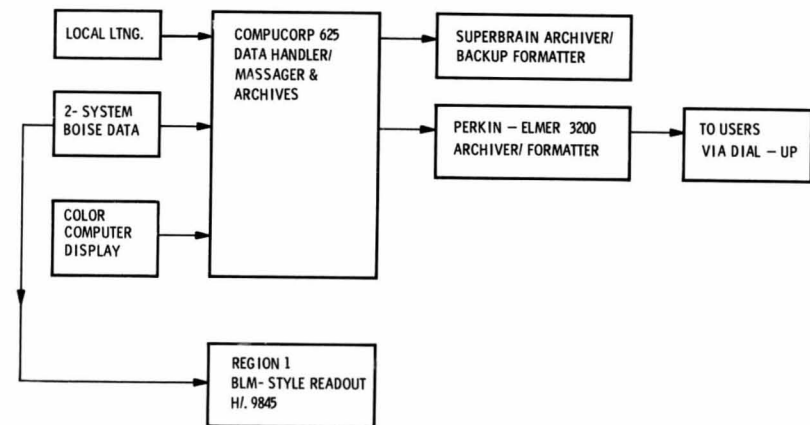
OUR HANDLER → WRITES INPUT ASCII LINE, PA PROGRAM 0 OUTPUT, WITH MONTH AND DAY TACKED ON, TO THE CURRENT BUFFER FILE

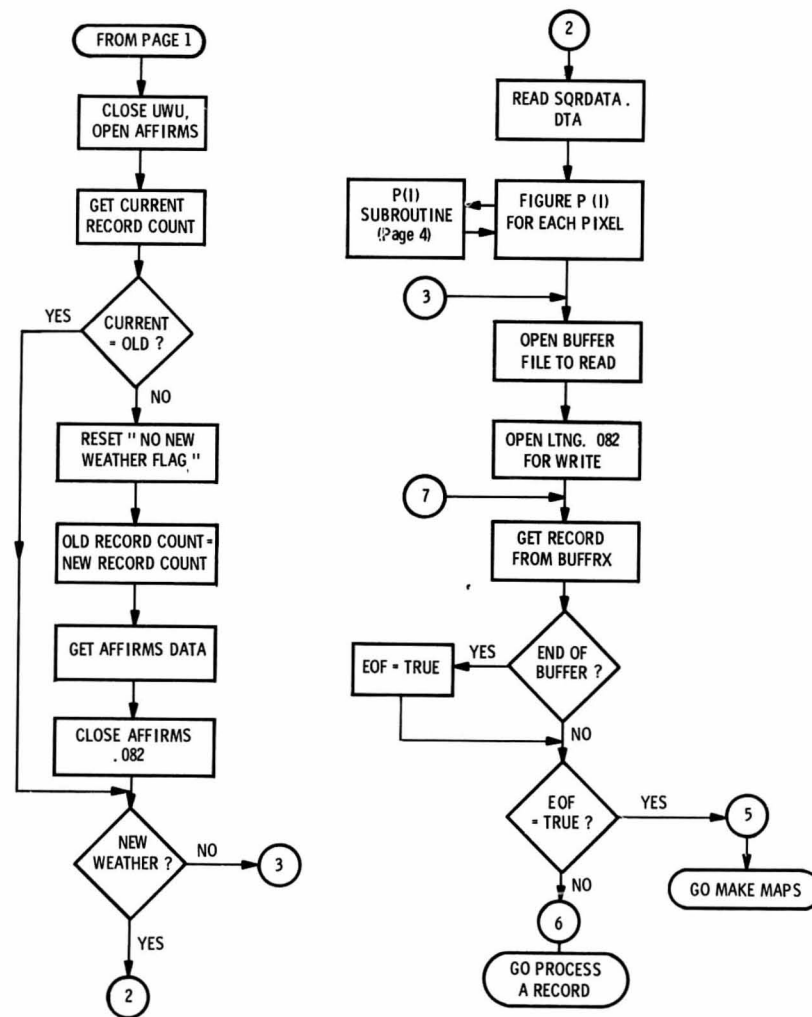
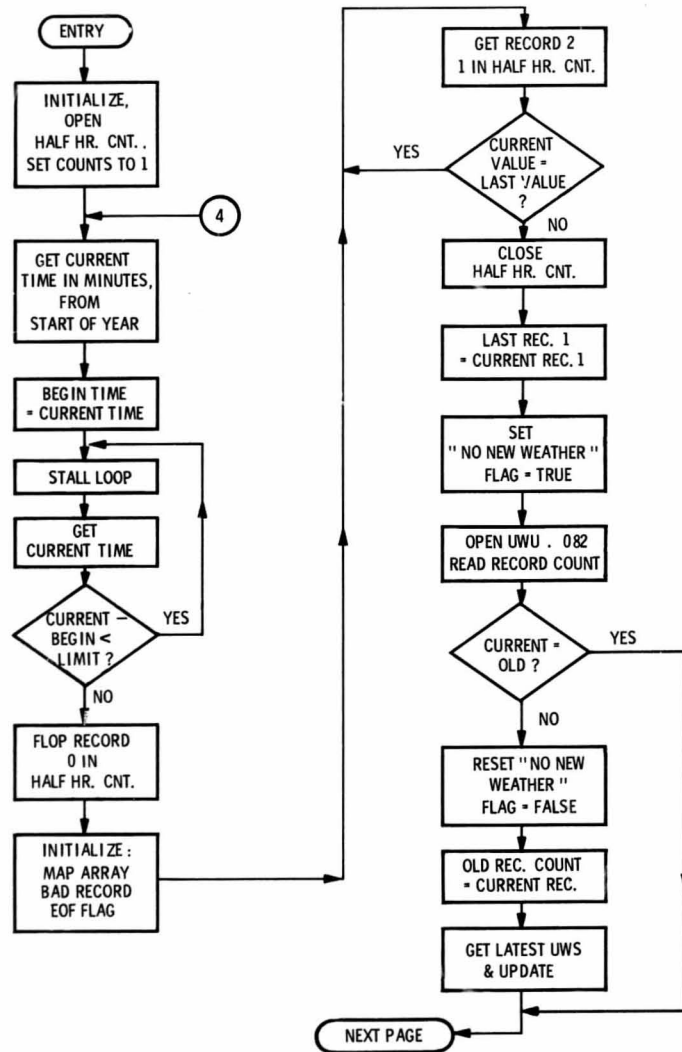
OTHER HANDLER → SAME AS ABOVE, BUT WRITES TO VERBOSE . BOI FILE

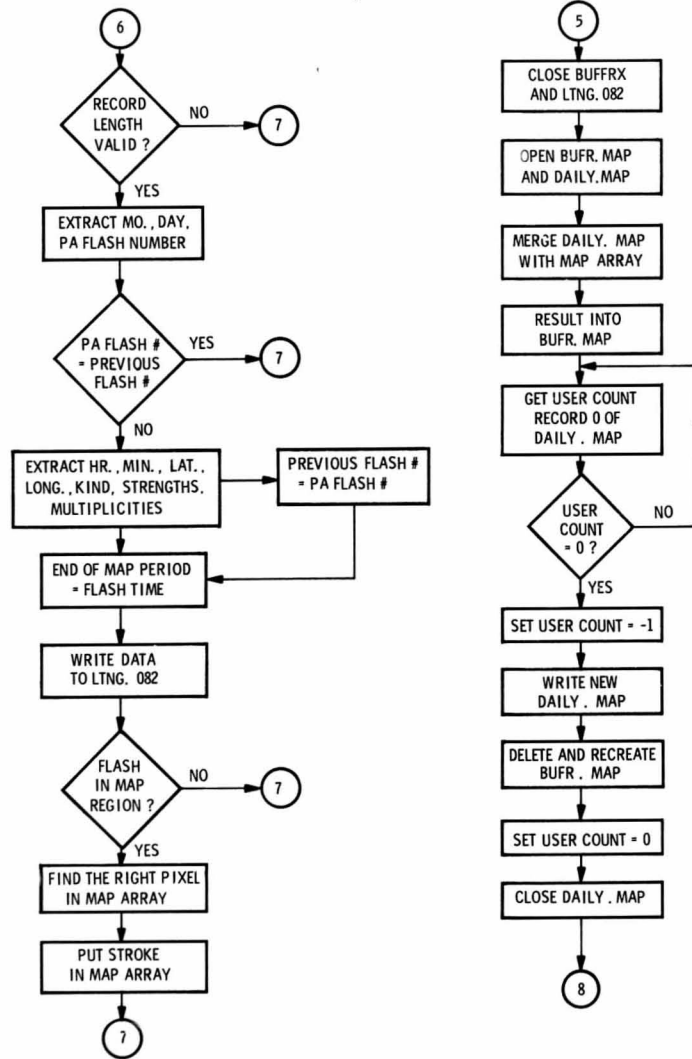
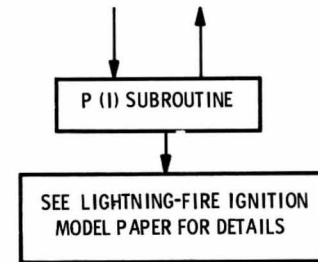
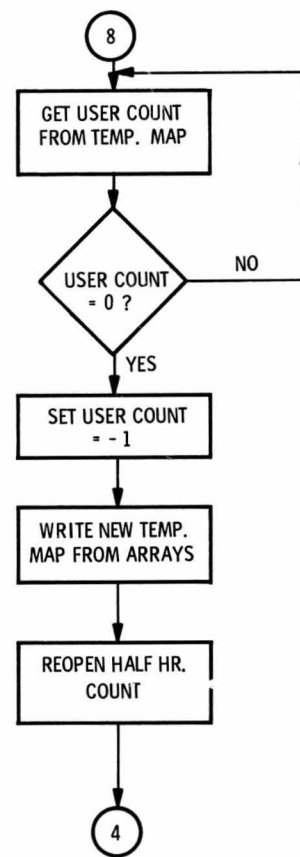
AFFIRMS HANDLER → PASSES AFFIRMS DATA AROUND OUR SMALL COMPUTER NETWORK

UPPER WIND HANDLER → PASSES UWSPEED DATA AS ABOVE

OUR NETWORK

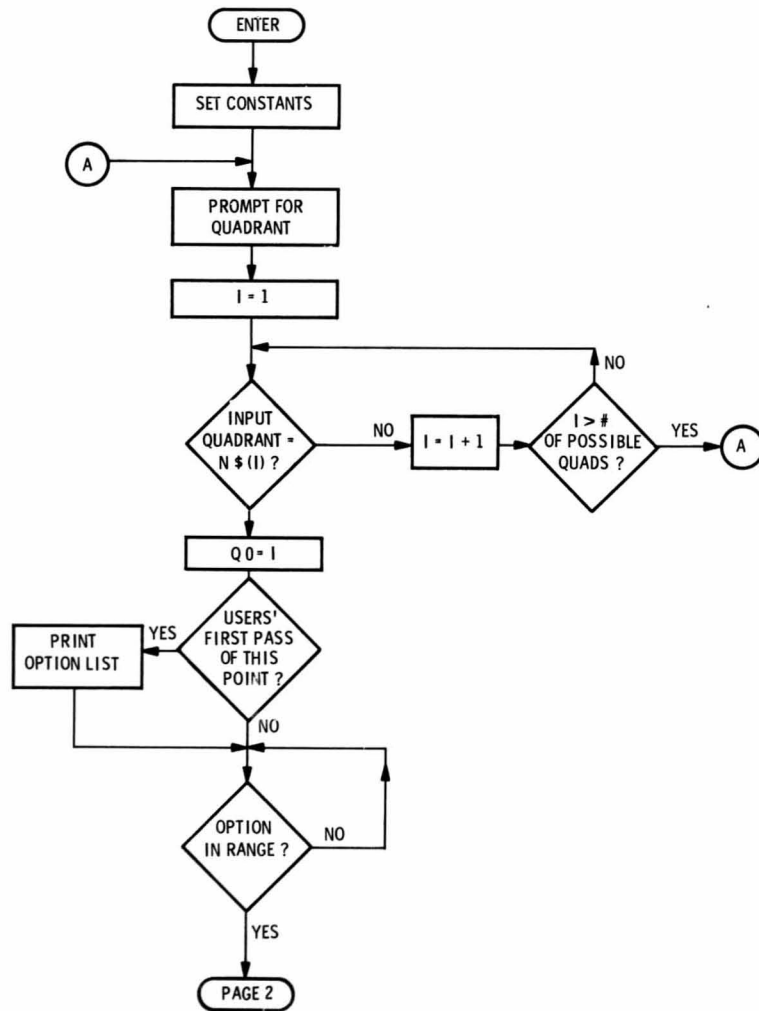




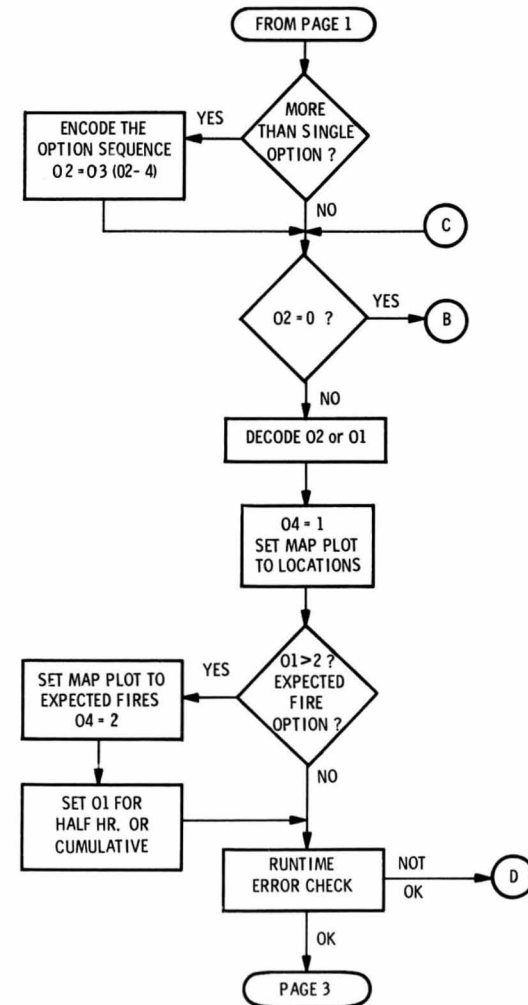
PERIODIC . BAS  
(Page 3)PERIODIC . BAS  
(Page 4)



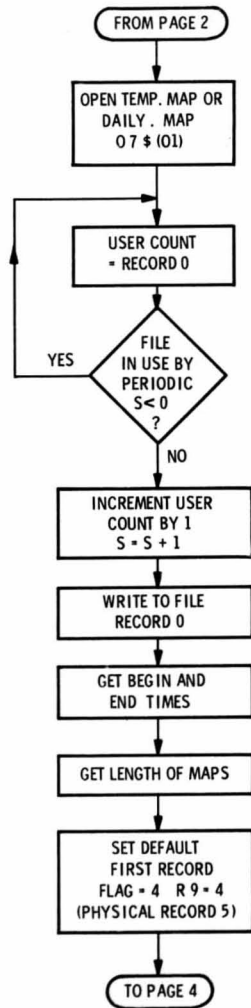
SHOWTIME . BAS  
(Page 1)



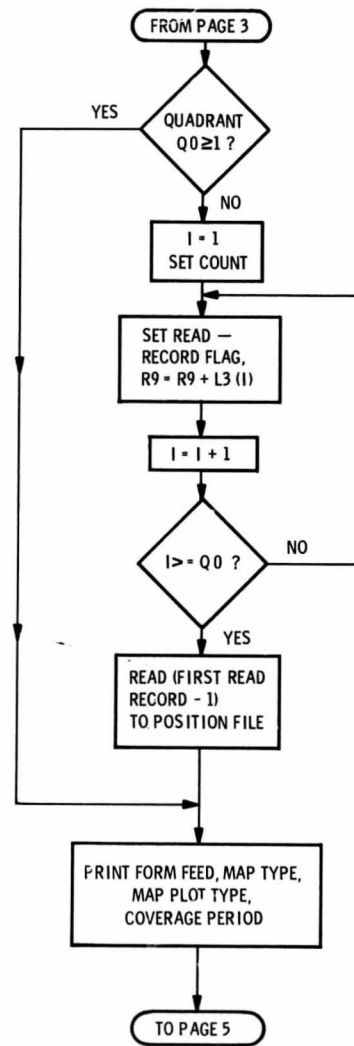
SHOWTIME . BAS  
(Page 2)



SHOWTIME . BAS  
(Page 3)

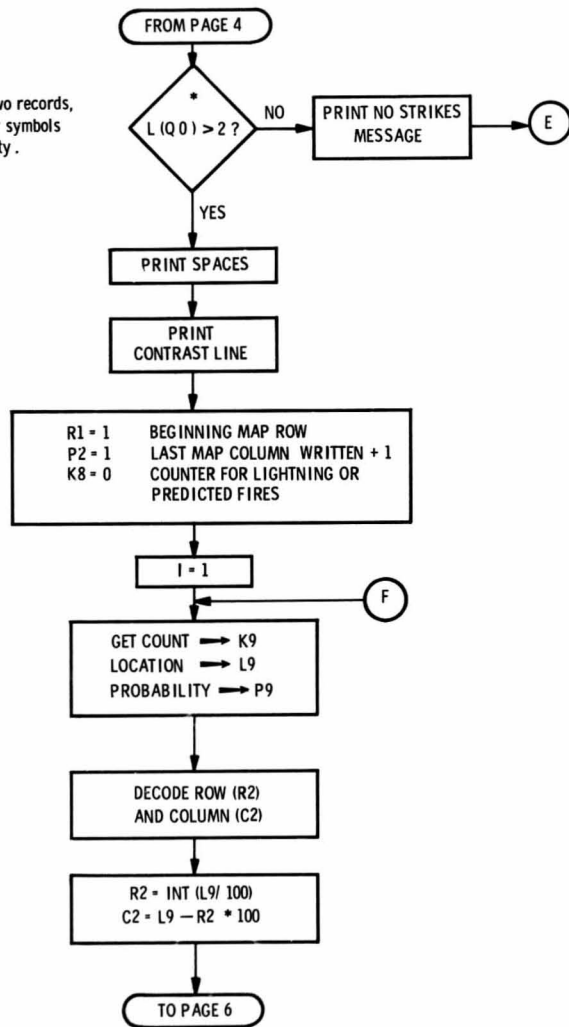


SHOWTIME . BAS  
(Page 4)

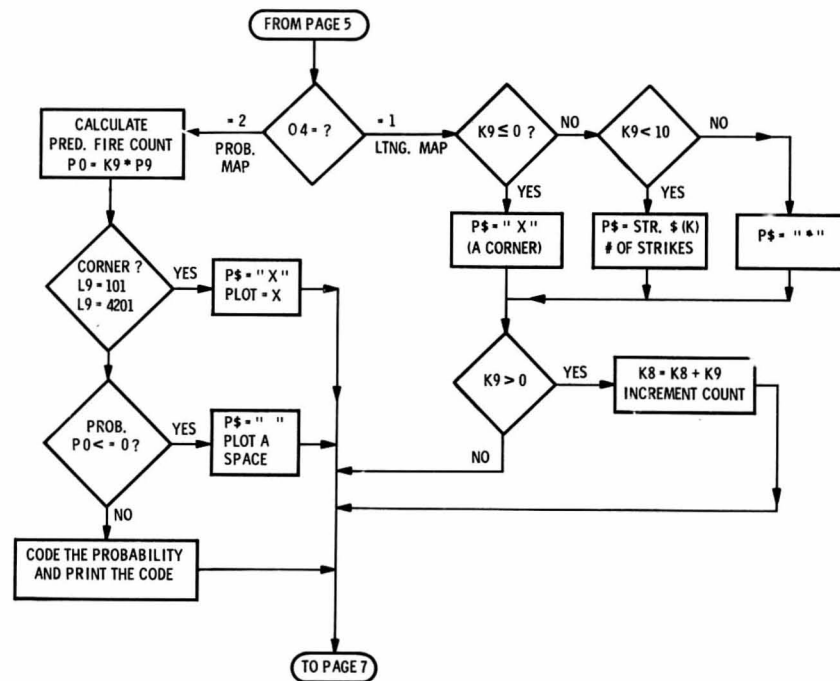


SHOWTIME . BAS  
(Page 5)

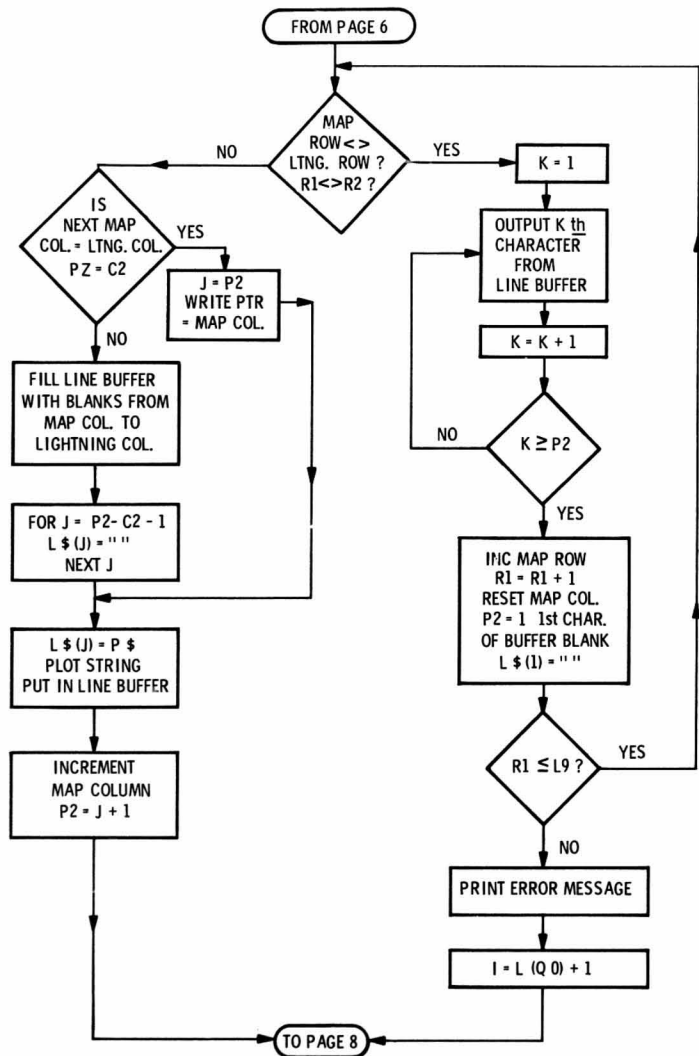
\* NOTE : If a map has only two records,  
they are the corner symbols  
and the map is empty .



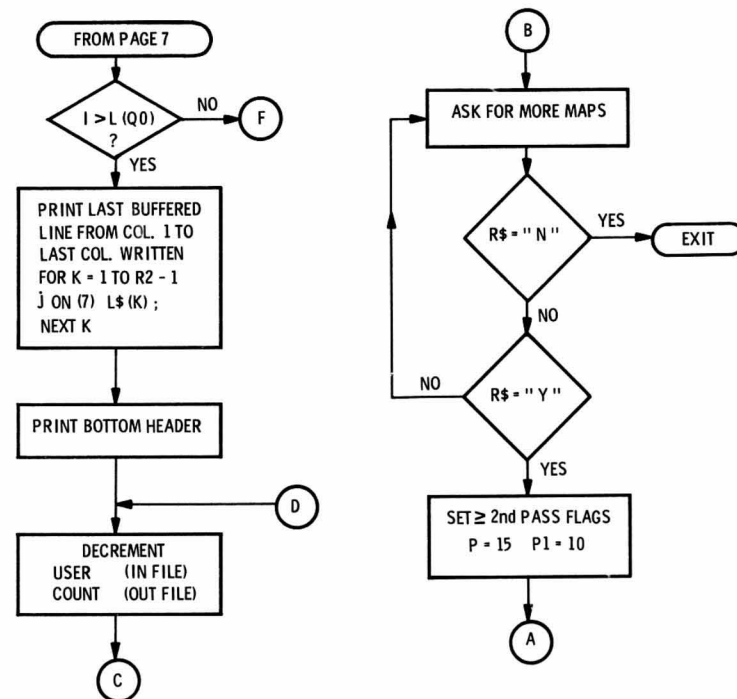
SHOWTIME . BAS  
(Page 6)



SHOWTIME . BAS  
(Page 7)



SHOWTIME . BAS  
(Page 8)



#####

THIS IS THE SET OF PROGRAMS FOR LLAFFS WRITTEN ON/FOR THE PERKIN-ELMER 3200 IN BASIC. THE ABBREVIATION : IS USED FOR PRINT AT TIMES IN THESE PROGRAMS. ALL OTHER FUNCTIONS ARE SPELLED OUT.

#####

```

10 REM PROGRAM SQRFIL.BAS -- CREATFS AND FILLS THE FILE SQRDATA.DTA
20 REM THE FILE CAN BE GIVEN A NAME OTHER THAN 'SQRDATA.DTA'
30 DIM F$(12),E$(5)
40 REM *****
50 REM PROMPT THE USER
60 REM
70 ONERROR GOTO 80
80 PRINT"NUMBER OF SQUARES YOUR ARFA IS SECTIONED INTO ?"
90 INPUT S0
100 ONERROR GOTO 110
110 PRINT"NAME FOR THE DATA FILE ? (TYPE 'D' FOR DEFAULT='SQRDATA.DTA')
120 INPUT F$
130 IF F$="D" THEN F$="SQRDATA.DTA"
140 REM *****
150 REM CREATE AND OPEN FILE
160 REM
170 ONERROR GOTO 210
180 CREATE F$,2,4
190 OPEN F$,1,1
200 GOTO 350
210 E$=FRR$(0):E=VAL(E$)
220 IF E=10 THEN : "ILLEGAL FILE NAME.":GOTO 100
230 IF E<>22 THEN : "ERR NO.": E : "AT LINE NO": ERL(0):STOP
240 PRINT"FILE " F$ " ALREADY EXISTS."
250 PRINT"TO DELETE " F$ : " THEN RECREATE IT, TYPE 1"
260 PRINT"TO STOP TYPE 0, TO TRY A NEW NAME, TYPE 2"
270 ONERROR GOTO 240
280 INPUT 01
290 IF 01=0 THEN STOP
300 IF 01=1 THEN DELETE F$:GOTO 170
310 GOTO 100
320 REM *****
330 REM FILL THE FILE
340 REM
350 FOR I=1 TO S0
360 ONERROR GOTO 370
370 PRINT"SQUARE NO.": I:"WEATHER STATION NRR.= "
380 INPUT W0
390 ONERROR GOTO 400
400 PRINT"SQR NO.": I : "FUEL TYPE INDEX.="
410 INPUT F0
420 W0=W0*100+F0

```

```

430 OUTFILE ON(1)W0
440 NEXT I
450 CLOSE1
460 PRINT F$ : " FILLED AND CLOSED."
470 END
*****
AFFIRMS UPDATING PROGRAM
THIS PROGRAM USES THE FILE AFFIRMS.082 (OR OTHER YEAR)
WHICH MUST BE EXTERNALLY CREATFD AT IMPLEMENTATION.
*****
10 REM AFFIRMS.BAS -- AFFIRMS.YYY FILE UPDATER
20 CLOSE:OPEN "CON":5,0
30 DIM A(73),S0$(1),Y$(4),F$(12)
40 PRINT ON(5)"PROGRAM AFFIRMS//ENTER YEAR OF DATA (2 DIGITS)":INPUT ON(5)Y$
50 F$="AFFIRMS.0"+Y$
60 CLOSE:OPEN F$,1,0:INFILE ON(1,0)Z,Z1
70 PRINT ON(5)"REWRITE (R) OR APPEND(A) ?":INPUT ON(5)S0$
80 IF S0$="R" THEN Z=0 ELSE IF S0$<>"A" GOTO 70
90 IF Z<1 THEN PRINT ON(5)"WARNING -- IN REWRITE MODE."
100 PRINT ON(5)"ENTER 0 TO STOP , ANY OTHER NUMBER TO CONTINUE."
110 ONERROR GOTO 100
120 INPUT ON(5)S0
130 IF S0=0 THEN STOP
140 PRINT ON(5)"ENTER MO,DAY,HR OF MEAS. (1 OR 2 DTGITS)":INPUT ON(5)M,D,H
150 T=(M-1)*44640+D*1440+H*60
160 ONERROR GOTO 210
170 FOR I=1 TO 73
180 PRINT ON(5)"ENTER STATION NO. " : I
190 PRINT ON(5)"LAL=":INPUT ON(5)L
200 PRINT ON(5)"FMI=":INPUT ON(5)F: GOTO 220
210 PRINT ON(5)CHRS(7) : "ERROR": GOTO 180
220 A(I)=L*100+F
230 NEXT I
240 ONERROR GOTO 370
250 REM (* APPEND NEW DATA TO END OF FILE *)
260 OUTFILE ON(1,Z+1)T,A(1),A(2),A(3),A(4),A(5),A(6),A(7),A(8)
270 OUTFILE ON(1)A(9),A(10),A(11),A(12),A(13),A(14),A(15),A(16),A(17)
280 OUTFILE ON(1)A(18),A(19),A(20),A(21),A(22),A(23),A(24),A(25),A(26)
290 OUTFILE ON(1)A(27),A(28),A(29),A(30),A(31),A(32),A(33),A(34),A(35)
300 OUTFILE ON(1)A(36),A(37),A(38),A(39),A(40),A(41),A(42),A(43),A(44)
310 OUTFILE ON(1)A(45),A(46),A(47),A(48),A(49),A(50),A(51),A(52),A(53)
320 OUTFILE ON(1)A(54),A(55),A(56),A(57),A(58),A(59),A(60),A(61),A(62)
330 OUTFILE ON(1)A(63),A(64),A(65),A(66),A(67),A(68),A(69),A(70),A(71)
340 OUTFILE ON(1)A(72),A(73)
350 Z=Z+9:OUTFILE ON(1,0)Z,Z1
360 CLOSE: PRINT ON(5)"DATE " : T : " APPENDED TO FILE " : F$:STOP
370 PRINT ON(5)"ERROR" : ERR$(165) : " LINE" : ERL(0)
380 END
*****

```

```

UPPER WIND SPEED UPDATE PROGRAM
THIS PROGRAM USES THE FILE UWU.0A2 (OR OTHER YEAR)
WHICH MUST BE EXTERNALLY CREATED AT IMPLEMENTATION.
*****
10  REM UWU.BAS -- UPPER WIND SPEED FILE (UWU.YYY) UPDATER
20  CLOSE:OPEN"CON";5,0
30  DIM W(4),G(3,3),C(3),S(3)
40  DIM Y$(4),S0$(1),F$(12),C$(12)
50  PRINT ON(5)"PROGRAM UWU"
60  PRINT ON(5)"YEAR PRESENTLY SET FOR 1982":Y$="A2"
70  F$="UWU.0"+Y$
80  CLOSE:OPENF$,1,0:INFILE ON(1,0)Z1
90  PRINT ON(5)"REWRITE (R) OR APPEND (A) ? "
100 INPUT ON(5)S0$
110 IF S0$="R" THEN Z1=0 ELSE IF S0$<>"A" GOTO 90
120 IF Z1<1 THEN PRINT ON(5)"WARNING -- IN REWRITE MODE.": GOTO 150
130 INFILE ON(1,Z1)U,H(1),H(2),H(3)
140 PRINT"LAST UWU RECORD IS " ; U ; H(1) ; H(2) ; H(3)
150 PRINT"ENTER 0 TO STOP, ANY NUMBER TO RESUME UWU-RUN"
160 INPUT ON(5)I
170 IF I=0 THEN STOP
180 PRINT ON(5)"ENTER 500MB WIND SPD FOR BOISE":INPUT ON(5)W(1)
190 PRINT ON(5)"ENTER 500MB WIND SPD FOR SPOKANE":INPUT ON(5)W(2)
200 PRINT ON(5)"ENTER 500MB WIND SPD FOR GRTFALLS":INPUT ON(5)W(3)
210 PRINT ON(5)"ENTER MO, DAY, HR OF MEAS. (1 OR 2 DIGITS)"
220 INPUT ON(5)M,D,H
230 T=(M-1)*44640+D*1440+H*60
240 OUTFILE ON(1,Z1+1)T,W(1),W(2),W(3)
250 Z1=Z1+1:OUTFILE ON(1,0)Z1
260 CLOSE: PRINT ON(5)T;W(1);W(2);W(3);"APPENDED TO ";F$;" FOR ";M;D;H
270 END
*****
MONITOR PROGRAM
MONITOR USES SEVERAL FILES. THESE ARE SPECIFIC TO
THE APPLICATION, EXCEPT FOR BUFFR1.LTG AND BUFFR2.LTG.
THESE TWO ARE REQUIRED FOR PERIODIC.BAS. ALL FILES IN
MONITOR MUST BE EXTERNALLY CREATED AT IMPLEMENTATION.
*****
10  CLOSE 7:OPEN "CON";7,0
20  REM ***** PROGRAM SUPERMON
30  DIM L$(80),K1$(1),B0$(80),F$(12),Y$(2),M1$(2),D1$(2),X$(1),E$(5)
40  DIM A9$(1),N9$(1),D2$(1),C1$(1),C2$(1),C3$(1),C4$(1),C5$(1)
50  DIM B$(10,2),A(73)
60  REM
70  D2$=CHR$(18):C1$=CHR$(1):C2$=CHR$(2):C3$=CHR$(3):C4$=CHR$(4)
80  C5$=CHR$(5):A9$=CHR$(6):N9$=CHR$(21):F=1:U1=1
90  I1=1:I2=2:S1=1
100 B$(1)="BUFFR1.LTG":B$(2)="BUFFR2.LTG"
110 PRINT ON(7)D2$: C2$

```

```

120 ONERROR GOTO 710
130 REM *****
140 OPEN "HALFHR.CNT",4,0 &
150 OPEN "VERBOSE.BOI",2,1:OPEN "BUFFR1.LTG",1,1
160 GOTO 250
170 REM *** CHECK FOR END OF HALF HOUR PERIOD *****
180 INFILE ON(4,0)S0
190 IF S0=S1 THEN RETURN
200 CLOSE U1:F=F+S1:S1=S0
210 OPEN B$(F):U1,1
220 OUTFILE ON(4,1)S1
230 RETURN
240 REM ***** WAIT FOR INPUT ON(7) FROM COMPUTORP
250 LINPUT ON(7)B0$
260 X$=B0$(1,1):L$=B0$(12,):T0=ASC(X$)
270 ONTO GOTO 300,330,470,360
280 PRINT ON(7)D2$: C5$;"PE:INVALID COMMAND": GOTO 250
290 REM..... OUR LTNG INFO HANDLER .....
300 OUTFILE ON(U1)L$
305 GOSUB 180
310 GOTO 250
320 REM..... BOISE LTNG INFO HANDLER .....
330 OUTFILE ON(2)L$
340 GOTO 250
350 REM ..... UPPER WIND HANDLER .....
360 GOSUB 680
370 F$="UWU.0"+Y$:CLOSE 5:OPEN F$,5,0:INFILE ON(5,0)Z,Z1
380 IF Z=Z1 THEN PRINT ON(7)N9$: GOTO 250
390 PRINT ON(7)A9$
400 Z1=Z1+1
410 INFILE ON(5,Z1)A(1),A(2),A(3)
420 FOR I=1TO3:PRINT ON(7)A(I):NEXT I
430 INPUT ON(7)K1$: IF K1$<>A9$ GOTO 420
440 IF Z=Z1 THEN PRINT ON(7)C3$ ELSE PRINT ON(7)C4$: GOTO 400
450 OUTFILE ON(5,0)Z,Z1:CLOSE 5: GOTO 250
460 REM..... READ LATEST AFFIRMS DATA AND PASS TO COMPUTORP .....
470 GOSUB 680
480 F$="AFFIRMS.0"+Y$:CLOSE 5:OPEN F$,5,0:INFILE ON(5,0)Z,Z1
490 IF Z=Z1 THEN PRINT ON(7)N9$: GOTO 250
500 PRINT ON(7)A9$
510 Z1=Z1+9
520 INFILE ON(5,Z-8)T,A(1),A(2),A(3),A(4),A(5),A(6),A(7),A(8)
530 INFILE ON(5)A(9),A(10),A(11),A(12),A(13),A(14),A(15),A(16),A(17)
540 INFILE ON(5)A(18),A(19),A(20),A(21),A(22),A(23),A(24),A(25),A(26)
550 INFILE ON(5)A(27),A(28),A(29),A(30),A(31),A(32),A(33),A(34),A(35)
560 INFILE ON(5)A(36),A(37),A(38),A(39),A(40),A(41),A(42),A(43),A(44)
570 INFILE ON(5)A(45),A(46),A(47),A(48),A(49),A(50),A(51),A(52),A(53)
580 INFILE ON(5)A(54),A(55),A(56),A(57),A(58),A(59),A(60),A(61),A(62)
590 INFILE ON(5)A(63),A(64),A(65),A(66),A(67),A(68),A(69),A(70),A(71)

```



```

600 INFILE ON(5)A(72),A(73)
610 PRINT ON(7)T
620 FOR I=1 TO 73:PRINT ON(7)A(I):NEXT I
630 INPUT ON(7)K1$: IF K1$<>A9$ THEN "BAD BLK": GOTO 610
640 IF Z=Z1 THEN PRINT ON(7)C3$ ELSE PRINT ON(7)C4$: GOTO 510
650 OUTFILE ON(5,0)Z,Z1:CLOSE 5
660 GOTO 250
670 REM ..... GET DATE .....
680 D$=GETDATE$(0)
690 Y$=D$(7,8):M1$=D$(1,2):D1$=D$(4,5):RETURN
700 REM..... ERROR HANDLER .....
710 E$=ERR$(0):E=VAL(E$)
720 PRINT ON(7)D2$;C5$;PRINT ON(7)"ERROR NO -";E*;" AT LINE NO. ";ERL(0)
730 STOP
740 END

```

\*\*\*\*\*

PFRIODIC.....THE FILEMAKER AND PROBABILITY PROGRAM

PERIODIC USES SEVERAL FILES. ALL MUST BE CREATED AT THE

TIME OF IMPLEMENTATION. THE FILES ARE: HALFHR.CNT,

LTOTL.DTA, TEMP.MAP, RUFR.MAP, BUFR1.LTG, BUFR2.LTG,

LTNG.082, AND DAILY.MAP. LTNG.082 IS THE DATA ARCHIVE, AND MAY

NOT BE NECESSARY FOR SOME USERS.

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```

10 REM PROGRAM PERIODIC
20 REM FLOPS THE STATE OF RECORD NBR. 0 IN THE FILE 'HALFHR.CNT'
30 REM EVERY HALF HOUR. MAKES THE MAP 'TFMP.MAP' FOR SHOWTIME USERS.
40 DIM B$(10,2),K$(2),M1$(2),D$(2),H$(2),M2$(2),L$(80),C9(576)
50 DIM P$(4),T8$(2,4),T9$(2,4),S4$(6),S7$(6),M8$(1),M7$(2)
60 DIM L0(1000),K0(1000),L3(4),M9$(1,2),S8(2),L1$(6),L2$(7)
70 DIM D1$(8),T$(8),D9$(2),N9$(4),F1$(9),F2$(8),L5(4)
80 DIM S(6),S9(6),S3(6),S4(6),A(73),P(576),P9(1000),G(6)
90 REM *****
100 S(1)=2.856:S(2)=3.372:S(3)=3.896:S(4)=4.944:S(5)=7.04:S(6)=3.896
110 S9(1)=6.856:S9(2)=7.372:S9(3)=7.896:S9(4)=8.944:S9(5)=11.04
120 S3(1)=-86.83:S3(2)=149.21:S3(3)=173.83:S3(4)=201.13:S3(5)=231.29
130 S3(6)=173.83:B=620:C=.7854:Z6=76:S9(6)=7.896
140 A0=170:A9=-1401.65:B9=2822.16:T8=1.44293:Z6=.2
150 S4(1)=2:S4(2)=4:S4(3)=5:S4(4)=6:S4(5)=7:S4(6)=8
160 S1=1:M1=-1:T3=30:F1$="DAILY.MAP":X=117:Y=49:N7=0:N8=0
170 B$(1)="BUFR1.LTG":B$(2)="BUFR2.LTG":F2$="BUFR.MAP"
180 L9=47:R9=2:L8=114:R8=3:Z0=0:Y1=24:C6=6
190 S2=1:C1=1:C2=2:C3=3:C4=4:Q0=250:F=2
200 G(1)=0:G(2)=30:G(3)=60:G(4)=130:G(5)=1000
210 FOR I=1 TO 5:G(I)=G(I)*100/250:NEXT I
220 FOR I=1 TO 576:C9(I)=1:NEXT I
230 REM *****
240 OPEN"HALFHR.CNT",1,0
250 OUTFILE ON(1,0)S1:OUTFILE ON(1,1)S1
260 REM *****

```

```

270 GOSUB 480
280 T9=T0
290 REM *****
300 FOR I=1 TO 1500:Q=0:NEXT I
310 GOSUB 480
320 IF T0-T9<T3 GOTO 300
330 S1=S1*M1:OUTFILE ON(1,0)S1: GOTO 560
340 REM *****
350 G1=1
360 IF Z<G(G1) THEN RETURN
370 IF G1=5 THEN RETURN ELSE G1=G1+1
380 GOTO 360
390 REM *****
400 GOSUB 480
410 T1=T0
420 INFILE ON(X3,0)S
430 IF S=Z0 THEN OUTFILE ON(X3,0)M1:RETURN
440 GOSUB 480
450 IF T0-T1>3 THEN OUTFILE ON(X3,0)M1 ELSE 420
460 RETURN
470 REM *****
480 D1$=GETDATE$(0):T$=GETTIME$(0)
490 D9$=D1$(1,2):M=VAL(D9$)
500 D9$=D1$(4,5):D=VAL(D9$)
510 D9$=T$(1,2):H=VAL(D9$)
520 D9$=T$(4,5):M2=VAL(D9$)
530 T0=(M-1)*4640+D*1440+H*60+M2
540 RETURN
550 REM *****
560 L3(1)=2:L3(2)=Q0+2:L3(3)=2*Q0+2:L3(4)=3*Q0+2:P$="0000":F9=0
570 FOR I=0 TO 3:J=Q0*I+1
580 L0(J)=101:L0(J+1)=4201:K0(J)=-1:K0(J+1)=-1:P9(J)=0:P9(J+1)=0
590 NEXT I
600 GOTO 1130
610 REM *****
620 INFILE ON(1,1)S0
630 IF S0<>S2 THEN S2=S0:CLOSE1:RETURN
640 FOR I=1 TO 1500:D1=0:NEXT I
650 GOTO 620
660 REM *****
670 OPEN"LTOTL.DTA",2,2
680 INFILE ON(2,0)C8
690 FOR I=1 TO 576:INFILE ON(2)C9(I),Z:NEXT I
700 CLOSE2
710 F=F+S2:OPENR$(F),2,2
720 OPEN"LTNG.082",3,1
730 RETURN
740 REM *****
750 INFILE ON(2)L$

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```

760 IF EOF(2) THEN F9=-1
770 RETURN
780 REM *****
790 IF LEN(L$)<>75 THEN RETURN
800 M1$=L$(1,2):D$=L$(3,4)
810 N9$=L$(5,6)
820 IF N9$=P$ THEN RETURN ELSE P$=N9$
830 H$=L$(10,11):M2$=L$(13,14)
840 L1$=L$(26,31):L6=VAL(L1$):L2$=L$(36,42):L7=VAL(L2$)
850 K$=L$(49,50)
860 L1$=L$(54,54):D9=VAL(L1$)
870 S8$=L$(57,62):M8$=L$(65,65):S7$=L$(67,72):M7$=L$(75,75)
880 S8(D9)=VAL(S8$):M9$(D9)=M8$
890 IF D9=C1 THEN D9=C2 ELSE D9=C1
900 S8(D9)=VAL(S7$):M9$(D9)=M7$
910 T9$(1)=M1$:T9$(2)=D$:T9$(3)=H$:T9$(4)=M2$
920 OUTFILE ON(3)L6,L7,S8(1),S8(2),M9$(1),M9$(2),K$,M1$,D$,H$,M2$
930 L1=L9-L6:L2=L8-L7
940 IF ABS(L1)>=R9 THEN RETURN
950 IF ABS(L2)>=R8 THEN RETURN
960 Y2=Y1*INT((Y-L6)*C6)
970 X1=Y2+INT((X-L7)*C4)+1
980 C9(X1)=C9(X1)+1
990 IF L1>=Z0 THEN Z=0 ELSE L1=C2+L1:Z=-2
1000 IF L2>=Z0 THEN Z=Z+C4 ELSE L2=C3+L2:Z=Z+3
1010 C0=INT(L2*24)+C1:R0=INT(L1*21)+C1
1020 B0=R0*100+C0
1030 K=(Q0*(2-1))+C1
1040 IF (B0<=L0(K))OR(K>L3(Z)) GOTO 1060
1050 K=K+C1: GOTO 1040
1060 IF K>L3(Z) THEN L0(K)=B0:K0(K)=1:P9(K)=P(X1):L3(Z)=K:RETURN
1070 IF B0=L0(K) THEN K0(K)=K0(K)+C1:RETURN
1080 FOR I=L3(Z) TO KSTEP-1
1090 K0(I+1)=K0(I):L0(I+1)=L0(I):P9(I+1)=P9(I):NEYTI
1100 K0(K)=C1:L0(K)=B0:P9(K)=P(X1):L3(Z)=L3(Z)+1
1110 RETURN
1120 REM *****
1130 GOSUB 620
1140 GOSUB 1980
1150 GOSUB 670
1160 GOSUB 750
1170 IF F9 GOTO 1210
1180 GOSUB 790
1190 GOTO 1160
1200 RFM *****
1210 CLOSE2:CLOSE3
1220 OPEN"LTOTL.DTA",2,0
1230 INFILE ON(2,0)C8
1240 FOR I=1 TO 576:INFILE ON(2,I)7,C8:OUTFILE ON(2,I)C9(I),C8:NEXTI

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```

1250 CLOSE2
1260 OPEN F1$,2,0:OPEN F2$,3,1
1270 INFILE ON(2,3)L5(1),L5(2):INFILE ON(2,4)L5(3),L5(4)
1280 FOR I=1 TO 4
1290 K=(Q0*(I-1))+1:K1=L5(I)
1300 FOR J=1 TO K1
1310 INFILE ON(2)K4,L4,P4
1320 IF L0(K)>L4 GOTO 1390
1330 K4=K4+K0(K)
1340 OUTFILE ON(3)K4,L4,P9(K)
1350 K=K+1
1360 IF K<=L3(I) GOTO 1500
1370 IF J=K1 GOTO 1500
1380 J2=J+1: GOTO 1450
1390 IF L0(K)<L4 GOTO 1410
1400 OUTFILE ON(3)K4,L4,P4: GOTO 1500
1410 OUTFILE ON(3)K0(K),L0(K),P9(K)
1420 K=K+1:L5(I)=L5(I)+1
1430 IF K<=L3(I) GOTO 1320
1440 IF J=K1 GOTO 1500 ELSE J2=J
1450 FOR J1=J2 TO K1
1460 INFILE ON(2)K4,L4,P4
1470 OUTFILE ON(3)K4,L4,P4
1480 NEXTJ1
1490 J=J1
1500 NEXTJ
1510 IF K>L3(I) GOTO 1560
1520 FOR J=K TO L3(I)
1530 OUTFILE ON(3)K0(J),L0(J),P9(J)
1540 L5(I)=L5(I)+1
1550 NEXTJ
1560 NFXTI
1570 CLOSE3:OPEN F2$,3,2
1580 X3=2:GOSUB 400
1590 OUTFILE ON(2,2)T9$(1),T9$(2),T9$(3),T9$(4)
1600 OUTFILE ON(2,3)L5(1),L5(2):OUTFILE ON(2,4)L5(3),L5(4)
1610 INFILE ON(3)K4,L4,P4
1620 IF EOF(3) GOTO 1650
1630 OUTFILE ON(2)K4,L4,P4
1640 GOTO 1610
1650 CLOSE3:DELETE F2$:CREATE F2$,2,12
1660 OUTFILE ON(2,0)Z0:CLOSE2
1670 RFM *****
1680 OPEN"TEMP.MAP",5,0
1690 X3=5:GOSUB 400
1700 OUTFILE ON(5,1)T8$(1),T8$(2),T8$(3),T8$(4)
1710 OUTFILE ON(5,2)T9$(1),T9$(2),T9$(3),T9$(4)
1720 FOR I=1 TO 4:L3(I)=L3(I)-(Q0*(I-1)):NFXTI
1730 OUTFILE ON(5,3)L3(1),L3(2)

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1740 OUTFILE ON(5,4) L3(3), L3(4)
1750 FOR I=0 TO 3
1760 K=Q0*I
1770 FOR J=K+1 TO K+L3(I+1)
1780 OUTFILE ON(5) K0(J), L0(J), P9(J)
1790 NEXT J
1800 NFXTI
1810 OUTFILE ON(5,0) Z0
1820 CLOSE5
1830 FOR I=1 TO 4: T8$(I)=T9$(I): NEXT I
1840 DELETE B$(F)
1850 CREATE B$(F), 2, 78
1860 OPEN"LTOTL.DTA", 1, 0
1870 INFILE ON(1,0) C8
1880 FOR I=1 TO 576
1890 INFILE ON(1) Z, Z1
1900 GOSUB 350
1910 IF G1<=Z1 THEN 1930
1920 OUTFILE ON(1, I) Z, G1: C8=-1
1930 C9(I)=G1
1940 NEXT I
1950 OUTFILE ON(1,0) C8: CLOSE1
1960 OPEN"HALFHR.CNT", 1, 0: GOTO 270
1970 RFM *****
1980 N9=-1
1990 OPEN"UWU.082", 2, 2: INFILE ON(2,0) Z, Z1
2000 IF Z=N7 GOTO 2030
2010 N9=0: N7=7: INFILE ON(2, N7) Z1, W1, W2, W3
2020 W=(W1+W2+W3)/3
2030 CLOSE2: OPEN"AFFIRMS.082", 2, 2: INFILE ON(2,0) Z, Z1
2040 IF Z=N8 GOTO 2150
2050 N9=0: N8=Z
2060 INFILE ON(2, Z-8) Z1, A(1), A(2), A(3), A(4), A(5), A(6), A(7), A(8)
2070 INFILE ON(2) A(9), A(10), A(11), A(12), A(13), A(14), A(15), A(16), A(17)
2080 INFILE ON(2) A(18), A(19), A(20), A(21), A(22), A(23), A(24), A(25), A(26)
2090 INFILE ON(2) A(27), A(28), A(29), A(30), A(31), A(32), A(33), A(34), A(35)
2100 INFILE ON(2) A(36), A(37), A(38), A(39), A(40), A(41), A(42), A(43), A(44)
2110 INFILE ON(2) A(45), A(46), A(47), A(48), A(49), A(50), A(51), A(52), A(53)
2120 INFILE ON(2) A(54), A(55), A(56), A(57), A(58), A(59), A(60), A(61), A(62)
2130 INFILE ON(2) A(63), A(64), A(65), A(66), A(67), A(68), A(69), A(70), A(71)
2140 INFILE ON(2) A(72), A(73)
2150 CLOSE2
2160 OPEN"LTOTL.DTA", 2, 0
2170 INFILE ON(2,0) C8: CLOSE2
2180 IF C8 THEN N9=0
2190 IF N9 THEN RETURN
2200 OPEN"SQORDATA.DTA", 2, 2
2210 FOR I=1 TO 576
2220 INFILE ON(2) P(I)

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2230 GOSUB 2300
2240 P(I)=P0
2250 NEXT I
2260 CLOSE2
2270 RETURN
2280 RFM *****
2290 RFM FIGURE PROBABILITY FOR ONE SQUARE
2300 S7=INT(P(I)/100): R1=P(I)-S7*100
2310 R0=S4(R1)*.16E-1
2320 L=INT(A(S7)/100): F0=A(S7)-L*100
2330 IF L<>6 THEN L=C9(I)
2340 D0=-S(L)/W
2350 F5=0: F4=1
2360 IF L=6 GOTO 2420
2370 F5=(S3(L)*W*S(L)+C*S(L)*S(L))/(S3(L)*W*S9(L)+C*S9(L)*S9(L))
2380 F4=1-F5
2390 F3=F0+(Z6-F0)*(1-EXP(D0)): F3=F3/100
2400 E=R0*(A0+B*F3)
2410 P1=(1+(E/B9)^T8)^A9
2420 F3=F0/100
2430 E=R0*(A0+B*F3)
2440 P2=(1+(E/B9)^T8)^A9
2450 P0=(F5*P1+F4*P2)*Z8
2460 RETURN
2470 RFM *****
2480 END
*****
SHOWTIME ..... FORMATTING AND OUTPUT PROGRAM
ALL FILES IN SHOWTIME HAVE ALREADY BEEN CREATED IN IMPLEMENTING
THE OTHER PROGRAMS.
*****
10 REM SHOWTIME
20 CLOSE7: OPEN"CON": 7, 0
30 DIM N$(9,4), P$(1), Q$(8), L$(1,73), Q0$(2), N1$(2,4), L1$(73)
40 DIM M$(2), M1$(2), M2$(2), M3$(2), D$(2), D2$(2), H$(2), H2$(2), Q3$(25,2)
50 DIM R$(1), Q9$(39), Q8$(22), Q7$(9,2), Q3(3), Q6$(10,2), Q5$(70), Q4$(15,2)
60 N$(1)="NORTHWEST": N$(2)="NORTHEAST"
70 N$(3)="SOUTHWEST": N$(4)="SOUTHEAST"
80 Q9$="WHICH QUADRANT WOULD YOU LIKE TO SEE ?"
90 Q8$="ENTER AN OPTION NUMBER"
100 Q7$(1)="TEMP. MAP": Q7$(2)="DATA Y. MAP"
110 Q6$(1)="HALF HOUR": Q6$(2)="CUMULATIVE"
120 G5$="*****"
130 Q4$(1)="LIGHTNING": Q4$(2)="EXPECTED FIRE"
140 Q3$(1)="STRIKES IN THE QUADRANT."
150 Q3$(2)="SQUARES EXPECTING FIRES."
160 Q3(1)=21: Q3(2)=43: Q3(3)=42
170 N1$(1)="NW": N1$(2)="NE": N1$(3)="SW": N1$(4)="SE": P=38: P1=1: L8=43
180 RFM *****

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190 REM GET USER INPUT
200 ONERROR GOTO 210
210 PRINT ON(7)Q9$(1,P) : " (NW,NF,SW,SE)"
220 INPUT ON(7)Q0$
230 REM *****
240 I=1
250 IF Q0$=N1$(I) THEN Q0=I: GOTO 280
260 I=I+1:IF I>4 GOTO 210 ELSE 250
270 REM *****
280 IF P=15 THEN 410
290 PRINT ON(7): PRINT ON(7)" OPTIONS"
300 PRINT ON(7)" LIGHTNING MAPS"
310 PRINT ON(7)" 1. LAST HALF HOUR"
320 PRINT ON(7)" 2. CUMULATIVE"
330 PRINT ON(7)" EXPECTED FIRE MAPS"
340 PRINT ON(7)" 3. LAST HALF HOUR"
350 PRINT ON(7)" 4. CUMULATIVE"
360 PRINT ON(7)" OTHERS"
370 PRINT ON(7)" 5. 1 AND 2"
380 PRINT ON(7)" 6. 3 AND 4"
390 PRINT ON(7)" 7. 2 AND 4"
400 REM *****
410 ONERROR GOTO 420
420 PRINT ON(7)Q8$(P1)
430 INPUT ON(7)O2
440 RFM *****
450 IF O2<1 OR O2>7 THEN 420
460 IF O2>4 THEN O2=O3(O2-4)
470 IF O2=0 GOTO 960
480 O4=INT(O2/10):O1=O2-(O4*10):O2=O4:O4=1
490 IF O1>2 THEN O4=2:O1=O1-2
500 RFM *****
510 ONERROR GOTO 920
520 REM : REQUESTED MAP
530 CLOSE2:OPEN Q7$(O1),2,0
540 INFILE ON(2,0)S
550 IF S<0 GOTO 540 ELSE OUTFILE ON(2,0)S+1
560 INFILE ON(2)M$,O$,H$,M1$
570 INFILE ON(2)M2$,O2$,H2$,M3$
580 INFILE ON(2)L(1),L(2)
590 INFILE ON(2)L(3),L(4)
600 R9=4
610 IF Q0=1 GOTO 640
620 FOR I=1 TO Q0-1:R9=R9+L(I):NEXT I
630 INFILE ON(2,R9)K9,L9,P9
640 PRINT ON(7): PRINT ON(7)CHR$(12)
650 PRINT ON(7)"THIS IS THE " : N$(Q0) : " " : Q6$(O1) : Q4$(O4) : "MAP."
660 PRINT ON(7)"THIS MAP COVERS THE PERION"
670 PRINT ON(7)"FROM : " : M$ : "/" : N$ : " " : H$ : " : " : M1$ : " (MDT)"

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680 PRINT ON(7)" TO : " : M2$ : "/" : O2$ : " " : H2$ : " : " : M3$ : " (MDT)"
690 IF L(Q0)>2 THEN 710 ELSE PRINT ON(7)
700 PRINT ON(7)"NO LIGHTNING IN THE " : N$(Q0) : " MAP AREA." : GOTO 910
710 PRINT ON(7)Q5$
720 PRINT ON(7)
730 REM *****
740 R1=1:P2=1:K8=0
750 FOR I=1 TO L(Q0)
760 INFILE ON(2)K9,L9,P9
770 R2=INT(L9/100):C2=L9-R2*100
780 ONO4Q0SUB 1010,1050
790 IF R1<>R2 THEN 830
800 IF P2=C2 THEN J=P2: GOTO 820
810 FOR J=P2 TO (C2-1):L$(J)=" :NEXTJ
820 L$(J)=P$:P2=J+1: GOTO 870
830 FOR K=1 TO P2-1: PRINT ON(7)L$(K) : :NEXTK: PRINT ON(7)
840 R1=R1+1:P2=1:L$(1)=" "
850 IF R1<=L8 GOTO 790
860 PRINT ON(7)"INTERNAL ERROR. UNABLE TO FINISH MAP." : I=L(Q0)+1
870 NEXTI
880 FOR K=1 TO P2-1: PRINT ON(7)L$(K) : :NEXTK: PRINT ON(7)
890 PRINT ON(7)
900 PRINT ON(7)"THERE WERE " : K8 : Q3$(O4)
910 PRINT ON(7)Q5$
920 INFILE ON(2,0)S:OUTFILE ON(2,0)S-1:CLOSE2
930 PRINT ON(7): PRINT ON(7)
940 GOTO 470
950 REM *****
960 PRINT ON(7)"MORE MAPS ? (Y OR N)"
970 INPUT ON(7)R$
980 IF R$="N" THEN STOP ELSE IF R$="Y" THEN P=15:P1=10: GOTO 200
990 GOTO 960
1000 RFM *****
1010 IF K9<0 THEN P$="X" ELSE IF K9<10 THEN P$=STR$(K9) ELSE P$="*"
1020 IF K9>0 THEN K8=K8+K9
1030 RETURN
1040 REM *****
1050 P0=K9*P9
1060 IF L9=1010RL9=4201 THEN P$="X":RETURN
1070 IF P0<0 THEN P$=" :RETURN
1080 K8=K8+1
1090 IF P0<=.2 THEN P$="1":RETURN
1100 IF P0<=.4 THEN P$="2":RETURN
1110 IF P0<=.8 THEN P$="3" ELSE P$="4"
1120 RETURN
1130 RFM *****
1140 END

```

Latham, Don J. LLAFFS—a lightning-locating and fire-forecasting system. Gen. Tech. Rep. INT-315. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1983. 44p.

This paper presents a system for locating lightning strikes and predicting the number of fire ignitions on forests and rangelands. This system uses variables representing weather and fuels and real-time lightning locations as inputs. Outputs from the system consist of printouts designed for use with overlays to map probable fire locations. The programs are designed to be used by field personnel having access to a micro- or minicomputer.

KEYWORDS: lightning, lightning location, ignition probability

The Intermountain Station, headquartered in Ogden, Utah, is one of eight regional experiment stations charged with providing scientific knowledge to help resource managers meet human needs and protect forest and range ecosystems.

The Intermountain Station includes the States of Montana, Idaho, Utah, Nevada, and western Wyoming. About 231 million acres, or 85 percent, of the land area in the Station territory are classified as forest and rangeland. These lands include grasslands, deserts, shrublands, alpine areas, and well-stocked forests. They supply fiber for forest industries; minerals for energy and industrial development; and water for domestic and industrial consumption. They also provide recreation opportunities for millions of visitors each year.

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